DOCUMENT RESUME

ED 066 876 88 EM 010 152

AUTHOR	Dunn, Alex; Wastler, Jean
TITLE	Computer-Assisted Instruction Project. Project REFLECT. Final Report.
INSTITUTION	Montgomery County Public Schools, Rockville, Md.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	72
NOTE	502p.
AVAILABLE FROM	CAI Program, c/o Einstein High School, 11135 Newport Mill Road, Kensington, Maryland 20795, Attn. Alex Dunn ($12.50)
EDRS PRICE	MF-$0.65 HC-$19.74
DESCRIPTORS	*Computer Assisted Instruction; Costs; *Curriculum Development; *Curriculum Evaluation; *Educational Development; *Educational Technology; Elementary Schools; High Schools; Instructional Materials; Junior High Schools; Program Descriptions; Staff Orientation; Teacher Education

ABSTRACT

Montgomery County, Maryland, a suburb of Washington, D.C., received funding for three years, beginning in June, 1968, to develop, use, validate, and evaluate instructional materials which test the potential of the computer in the learning process. The report covers (1) materials, development, use, and validation (includes a cost analysis); (2) the facility and technical operations; (3) staff development (local teachers were trained to write CAI curricula); and (4) observations to data and projections. (RH)

Computer-Assisted Instruction Project

WILLIAM M. RICHARDSON / DIRECTOR / DEPARTMENT OF ADVANCE PLANNING AND DEVELOPMENT / CATHERINE MORGAN / DIRECTOR / CAI PROJECT / FINAL REPORT BY ALEX DUNN & JEAN WASTLER / COVERING PERIOD FROM JULY 1, 1969–JUNE 30, 1971 / PROJECT REFLECT / TITLE III, E.S.E.A. of 1965 / JAMES W. JACOBS / ASSOCIATE SUPERINTENDENT / OFFICE OF EDUCATIONAL AND MANAGERIAL INFORMATION AND ANALYSIS / HOMER O. ELSEROAD / SUPERINTENDENT OF SCHOOLS / MONTGOMERY COUNTY PUBLIC SCHOOLS / ROCKVILLE, MARYLAND

ED 066876

WRITE A CONJUNCTION FOR THE FOLLOWING STATEMENTS

BILL PASSED THE TEST. BILL WILL GO HOME

ANSWER: BILL PASSED THE TEST AND BILL

PROJECT OFFICES / ALBERT EINSTEIN HIGH SCHOOL / **11135 NEWPORT MILL RD.** / KENSINGTON, MD 20795

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ED 066876

Computer-Assisted Instruction Project

PROJECT REFLECT / TITLE III / E.S.E.A. OF 1965
FINAL REPORT BY ALEX DUNN AND JEAN WASTLER
COVERING PERIOD FROM JULY 1, 1969 - JUNE 30, 1971

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Montgomery County Public Schools

EM 010 152

FOREWORD

Four years ago, computer-assisted instruction was still a dream in Montgomery County. Today, however, as a result of in-depth planning, teacher training, and the dissemination of project information, the concept of CAI has emerged as an effective media for using educational technology. As one might expect, this technique does not offer a panacea for *all* educational ills, but its effectiveness for learning has been favorably documented by this project. Many theorists and planners in the county feel that computer-assisted instruction is just coming of age and can be utilized as a new arm to support one of the best educational systems in the county.

Educators acknowledge that individualized instruction, designed to meet the varying needs of thousands of pupils, is the ideal method for teaching but that the resources necessary for implementing programs of such magnitude are too staggering to contemplate. With computer-assisted and computer-managed instruction, the student, the teacher, and the computer are all members of an interactive team. By combining the experience and knowledge of inspired teachers with the instructional design-systems approach to learning, we have determined that astonishing improvement is made in the learning process.

It should be pointed out that curriculum development by experienced teachers and its articulation into the classroom are the prime concerns of the project. Following rigorous task analysis of a concept or skill, the carefully described necessary student behaviors are sequenced to show their interrelationships. Assessment of student achievement is made upon entry into a program and at each critical point during instruction to assure mastery of the desired learnings. Instant feedback and positive reinforcement provide continuous information to the learner and the teacher. As a consequence, their roles, when provided with the myriad resources available from such a program, become significantly different from those they now assume.

I wish to express my sincere appreciation to the members of the Board of Education and to Dr. Homer O. Elseroad for their continued support and interest during this two-year period and for demonstrating their confidence in the project by providing local support; to Dr. James W. Jacobs, associate superintendent for educational and managerial information and analysis, for his concern and interest since January, 1971, when the project was included under the Office of Educational and Managerial Information and Analysis; and, finally, to Dr. William M. Richardson for serving as director of and mentor to the project since its beginning.

Catherine E. Morgan

ABSTRACT

Montgomery County, Maryland, a suburb of Washington, D. C., contains 494 square miles and a population of approximately 500,000. The public school system, the nineteenth largest in the nation with a present enrollment of 125,344, is widely known for its innovation in curriculum design, educational research, and instructional materials.

The project schools, Albert Einstein High School, Newport Junior High School, and Pleasant View Elementary School, are located on adjoining properties in a densely-populated section known as the Kensington-Wheaton area. The combined population of the three schools is 3,465.

In Montgomery County Public Schools, the Computer-Assisted Instruction (CAI) Project was initially funded under Title III of the Elementary and Secondary Education Act of 1965 for a three-year period, beginning in June, 1968. The objectives of the project were: (1) to develop, use, validate, and evaluate instructional materials which test the potential of the computer in the learning process; (2) to provide the county school system with a cadre of individuals capable of developing and using computer-assisted instruction and computer-managed instruction curricula and, further, to inform a large group of administrators, supervisors, and faculty members about the project and its activities; and (3) to make recommendations to Montgomery County Public Schools accompanied by the substantiating evaluations and necessary criteria upon which to base decisions. In meeting these stated objectives through the systematic application of scientific knowledge, methods, and research, the project has made a substantial contribution toward individualizing instruction. Montgomery County Public Schools, by supporting a computer-assisted instruction project, has attempted to solve some of the educational problems of learning by exploring the role of the computer in instruction. This "systems approach to education" involved the specification of behavioral objectives; the assessment of student achievement; the development of instructional strategies, testing, and revision of the instructional units; and, finally, the packaging and administering of a validated learning system. This unique approach to learning has characterized the CAI Project. In addition, it has been the goal of this project to determine where, with whom, by what techniques, and in what context computer-assisted instruction can improve the learning process of the 125,000 Montgomery County elementary and secondary students. Learning is defined as a change in the behavior of the individual. Thus, if we are to modify human behavior in the educational process, we must explore the avenues of change offered by educational technology. At a time when this technology offers new innovative techniques for improving the learning environment of the student, this annual report provides educators with the documentation of the activities of a large public school system in the institution and implementation of computer-assisted instruction.

The IBM 1500 Instructional System is utilized in the project. The IBM 1130 computer and project offices are located in the high school with student terminals in both the elementary and secondary schools. Special technical knowledge relating to air-conditioning, cable installation, and program demonstrations is necessary for the effective performance of this system. In addition, software programs which provide curriculum authors and classroom teachers with information formatted for easy use have been written at the project, while some programs have been acquired from other installations. These packages provide information in the areas of item analysis, hierarchy validation, and student use.

The supporting teacher program, instituted during the first year, has continued to be an integral part of the project. In this vital program, regular classroom teachers come to the CAI Project one day every

two weeks on a released time basis to attend a training course and, after its completion, join project design teams to write CAI curriculum. Thus far, 39 supporting teachers have been trained to write individualized materials during the period from October, 1968, through June, 1971. These supporting teachers, all of whom are trained in the writing of behavioral objectives and criterion test items, design and develop modular instructional packages for the computer. A project document, *Authoring Individualized Learning Modules: A Teacher Training Manual,* describes the program and provides all the instructional materials and activities necessary to conduct a similar course. With the orientation and training of more supporting teachers, a greater number of modular instructional packages are available. Approximately 40 modular instructional packages have been developed by classroom teachers and teacher specialists. These packages include elementary school arithmetic and language arts, junior high school science, senior high school chemistry and physics, senior high school mathematics, and other programs in French, social studies, geography, and industrial arts. In addition to training teachers to write curriculum, numerous seminars and demonstrations have been held for administrators, supervisors, teachers, and interested citizens of the community. Over 2,800 individuals attended these project-directed activities during the last two years. As additional curriculum was developed, student use of the terminals has risen considerably.

In 1969-71, some 1,400 students used the terminals a total of 1,800 hours compared to the approximately 1,500 students who utilized the terminals in 1970-71 for a total of 4,100 hours. Thus, the development of more software increased student on-line interaction more than 100 per cent.

It should be noted that as project activities increased, evaluation of the use of the modules and the receptivity by students has been undertaken. Criterion referenced tests have been used to determine the validity and efficiency of the materials and norm-referenced standardized tests utilized to determine CAI effectiveness when compared with other methods of instruction. Receptivity of the modules and the mode of presentation have been ascertained through attitude-measuring instruments and student and teacher interviews.

Finally, this document includes a cost analysis of using computer hardware in the instructional process and the cost involved in developing curriculum materials for the computer. Projections indicate that CAI and CMI costs will be considerably less in the future, providing individualized instruction on the time-shared computer at a much lower cost per student hour.

As class sizes continue to be a primary concern among educators everywhere and since any substantial decrease in student-teacher ratio is virtually impossible to achieve in most educational environments, technological support provides an alternative. Because of the accessible resources of the instructional programs and the managerial assistance provided by the computer, the teacher is freed to direct more concern to the problems of the individual student.

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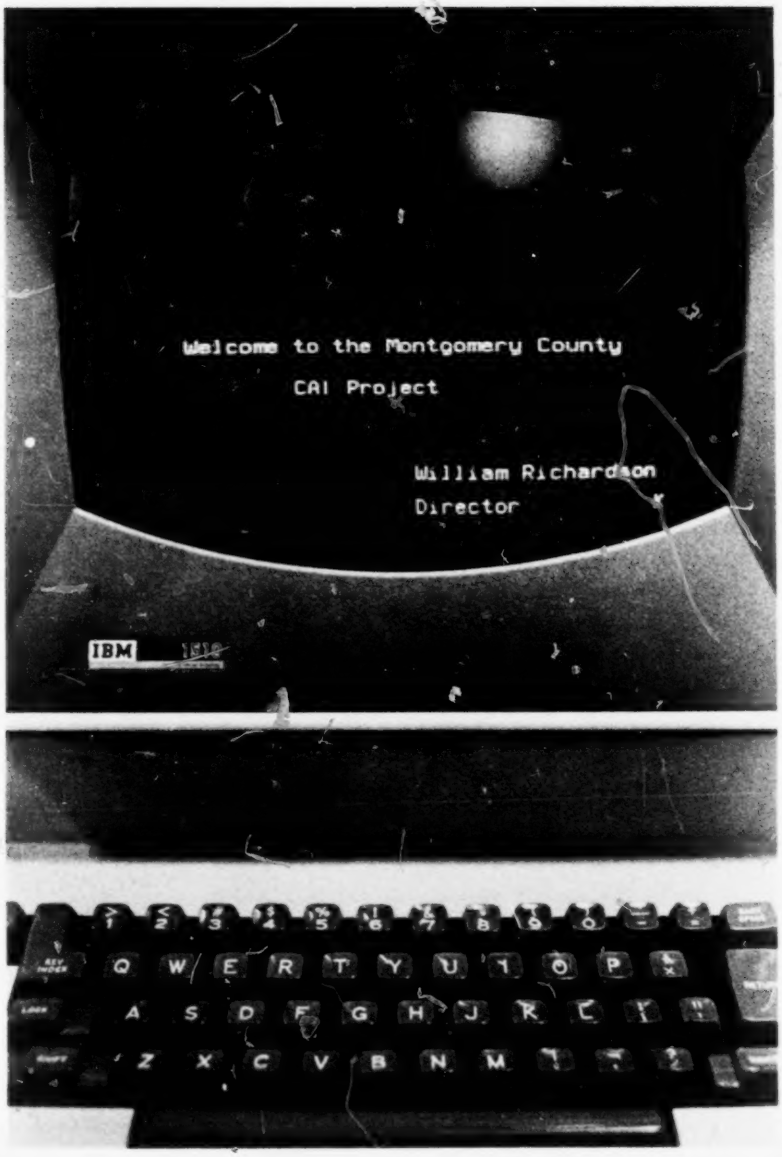
The materials developed by the Computer-Assisted Instruction Project from June, 1968, through June, 1971, are in the Public Domain. Curriculum is continually being revised so that programs now in use may differ from those described in this document.

I. INTRODUCTION



Welcome to the Montgomery County
CAI Project

William Richardson
Director

THE PROJECT

Demonstration of the feasibility of staff involvement at all levels in the use of computer-assisted instruction (CAI) as an instructional medium and assessment of the role of CAI in an operational K-12 school setting are the goals of this project. Funded under Title III of the Elementary and Secondary Education Act of 1965, with support from the Montgomery County (Maryland) Public Schools, the project's terminal objective is the design of a model plan which can be utilized by other public school systems in the implementation of validated and feasible CAI technologies.

Determinations of where, with whom, by what techniques, and in what context computer-assisted instruction can improve the learning process in a large public school system are being accomplished through the validation and evaluation of CAI materials developed and adapted by the project staff. In this Research into the Feasibility of Learnings Employing Computer Technology (REFLECT), computer-assisted instruction is viewed as but one instructional component of a comprehensive, individualized, multimedia learning system design. Remote time-shared computer terminals in Pleasant View Elementary School and Albert Einstein High School are cable-connected to a computer and its peripheral equipment located in the Kensington, Maryland, high school.

Primary efforts in materials development and evaluation are in the areas of elementary arithmetic, junior high science, senior high mathematics, and senior high science (chemistry and physics). Other areas in which modular instructional packages are being designed and tested include foreign language, social studies, and elementary language arts.

Project activities were divided into three one-year phases. The first year (June 1, 1968, to June 26, 1969) of the project was devoted to planning, staff orientation and training, and facility development. (The project's first annual report summarized the efforts and accomplishments of the first year.) Phase II included adaptation and development of CAI modular instructional packages (MIP's) which utilize a variety of CAI techniques and strategies for various student target populations, trial use with students, and validation of the modular instructional packages. The third phase, which began June 27, 1970, included the formal evaluation of CAI materials, documentation, reporting of findings, and the development of the model plan for the introduction and use of computer-assisted instruction in a public school environment.

This document summarizes the materials development, facility and technical operations, and staff development activities of Phases II and III. While some observations to date are included in this document, other publications to be produced during the summer and fall of 1971 will focus on the evaluation of CAI materials, the role of the teacher, and the model plan. (Recommendations regarding computer-assisted instruction use by Montgomery County Public Schools from 1971 to 1974, and from 1974 to 1979, are included in this document in the observations and recommendations sections).

THE PROJECT STAFF

The project director, a secretary to the director, five teacher specialists, two teacher aides, a technical systems manager, a senior programmer, and three instructional programmers were full-time employees during Phase II. Additional support was provided by part-time employees, including a clerk-typist, a computer operator, three instructional programmers, a student assistant graphic artist, and 16 classroom teachers who devoted 10 per cent of their time to the project.

Dr. William M. Richardson
Project Director
June, 1968 to December 1970

During Phase III, there was some variation in the number of staff positions. Only four teacher specialists were employed for that period; the programming staff consisted of the senior programmer, a junior programmer, and four part-time programmers, and there were fewer classroom teacher authors participating.

Mrs. Catherine E. Morgan
Acting Project Director
January, 1970 to June, 1971

PROJECT OBJECTIVES AND PROGRESS TOWARD THEM

All objectives are stated in terms of accomplishment of the activities at the conclusion of the three-year period (June, 1971). Although this document's principal intent is to summarize the activities of the second and third years of the project, the progress which is specified for the project objectives includes efforts from the project's initiation.

Extent of achievement of objectives incorporated the techniques implied in the objective statements. This evaluation was aided by analyzing (1) the Maryland State Department Title III evaluation committees' summaries, (2) comments and requests from other CAI installations, and (3) assessments by the project staff.

Objective A

THE DESIGN, DEVELOPMENT, CONDUCTION, VALIDATION, AND DOCUMENTATION OF AT LEAST THREE DIFFERENT TRAINING COURSES AND ORIENTATION PROGRAMS FOR VARIOUS LEVELS OF PUBLIC SCHOOL PERSONNEL. THESE PROGRAMS WILL COVER THE CONCEPTS NECESSARY FOR THE EFFECTIVE INSTALLATION AND USE OF CAI IN A PUBLIC SCHOOL SYSTEM.

Training courses were specifically designed to prepare staff members for their particular project roles. Programs were conducted for full-time project staff members who serve as teacher specialists, the part-time staff member classroom teachers who work as design team members, and the full-time and part-time programmers. A project document, *Authoring Individualized Learning Modules: A Teacher Training Manual,* reflects the knowledge and experience gained through the development, operation, and evaluation of the orientation and training programs for authors of computer-assisted instruction material and a summer workshop for classroom teachers. Orientations for classroom teachers whose students use the CAI materials included demonstrations of the programs in their subject area.

Supporting teachers (staff members 10 per cent of the time) participated in a training program which included some group discussions as a preface to individualized activity.

MCPS school administrators in a Department of Educational and Managerial Information Analysis two-day workshop on computer uses in education listened as Mr. Kenneth Walter, teacher specialist in staff development, described input.

More than 150 orientations of other types have occurred for MCPS system personnel. These sessions have been prepared for specific target populations. School board members, chief administrators of the school system departments, participants in subject and skill area workshops, faculties of some schools, and individual MCPS professional and supporting services personnel were among those participating. (See the Staff Development chapter for specific information on training and orientation programs during Phases II and III.)

Objective B

THE CREATION OF A CADRE OF TECHNICAL AND PROFESSIONAL PERSONNEL (5 – 10) WITHIN MCPS CAPABLE OF TRANSLATING CAI INSTRUCTIONAL STRATEGIES INTO EITHER THE COURSEWRITER II OR APL COMPUTING LANGUAGES.

Selection and training of teacher specialists, a systems manager, a senior programmer, a junior programmer, and instructional programmers provided the cadre of personnel with the capability for translating CAI instructional strategies into either Coursewriter II or APL computing languages. Staff changes have occurred for promotions within the system, funding limitations, and personal reasons.

June, 1971, staff members capable of translating CAI into the designated computer languages include the acting project director, four teacher specialists, the systems manager, the senior programmer, the junior programmer, and two part-time programmers. Two additional part-time programmers are capable of coding Coursewriter II programs.

FORTRAN and 1130 Assembly Language are not cited as part of this objective; however, capabilities within the staff for use of these languages were vital for research studies of Phase III. The system manager, senior programmer, and junior programmer know FORTRAN IV and 1130 Assembly Language.

Mathematics department members in the project high school were taught APL by the teacher specialist in mathematics curriculum. At least three of these mathematics teachers are capable of translating CAI instructional strategies into APL.

The Materials Development, Use and Validation chapter includes descriptions of Coursewriter II and APL Modular Instructional Packages which have been written and programmed.

A programmer at a 1510 Instructional Display puts a lesson segment into the computer using the COURSEWRITER II language.

Objective C

THE CREATION OF A CADRE OF SIX TEACHER SPECIALISTS WHO ARE CAPABLE OF DEVELOPING INSTRUCTIONAL PACKAGES FOR A GIVEN SUBJECT AREA, TO BE USED IN CONJUNCTION WITH THE COMPUTER.

This objective has been deemed accomplished.

Seven teacher specialists were trained and served on the staff during various project stages. The level of Phase II funding necessitated the reduction of the number of teacher specialists on the staff by one. The released person, who had been hired from outside MCPS for the CAI position, did not remain with the system. The teacher specialist in staff development was selected for an administrative internship near the end of Phase II; while he has left the project staff, he remained in the Montgomery County Public Schools system. Following the appointment of a teacher specialist to fill the vacant director's position in Phase III, a design team member was selected to join the staff in the vacant teacher specialist position.

Four teacher specialists on the staff in June, 1971, and the acting project director are, in fact, capable of developing instructional packages for a given subject area, to be used in conjunction with the computer. More than 50 modular instructional packages have been produced by or under the leadership of the teacher specialists. In the Materials Development, Use and Validation chapter of this document, the individual modular instructional packages developed by the Montgomery County Public Schools CAI staff are described.

Capabilities of these teacher specialists are not limited to the skills necessary for development of instructional packages for the computer. Rather, they are instructional technologists who, due to their competencies in individualizing instruction, can develop instructional materials for use in a variety of environments.

A teacher specialist prepares criterion items for the objectives in a hierarchy.

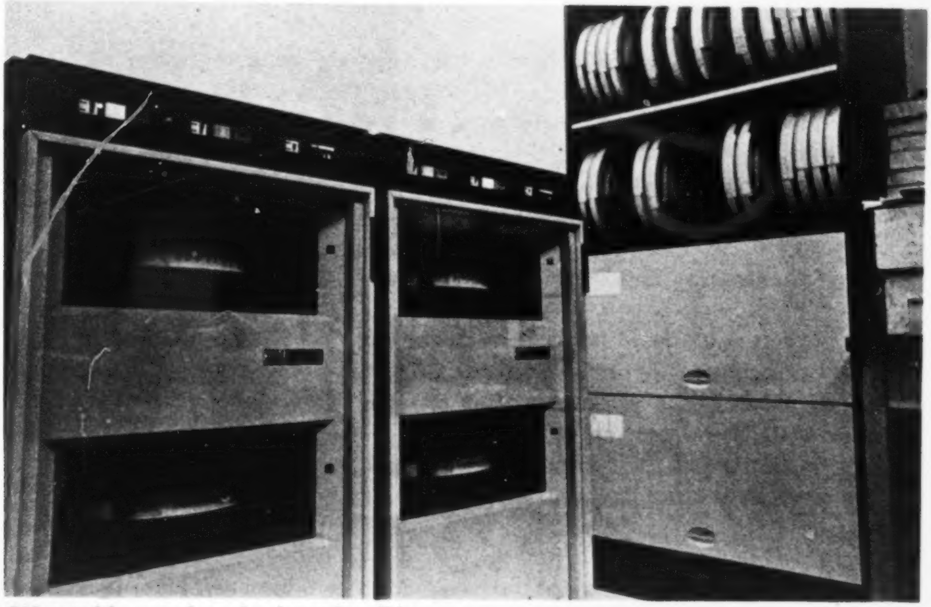
Objective D

THE DEVELOPMENT OF AN EVALUATION DOCUMENT WHICH WILL REVIEW AND EVALUATE EXISTING CAI MATERIALS THAT ARE AVAILABLE AND ADAPTABLE TO PUBLIC SCHOOL USE ON THE IBM 1500 INSTRUCTIONAL SYSTEM.

Plans for the survey and study of materials generated by other institutions were a part of the curriculum development subplan, a part of the Master Plan; the related excerpt from the curriculum development subplan, "Survey and Study of CAI Materials Generated by Other Institutions," is included in Materials Developed Elsewhere, a section of the Materials Development, Use and Validation chapter of this document.

The evaluation and use of materials developed elsewhere occurred during each project phase. Use of Florida State physics materials in a time-achievement correlation study, employment of University of Texas – McGraw-Hill English CAI punctuation segments in a comparative evaluation with other classroom strategies, utilization of Kansas City CAI Laboratory in Math and Science materials for individually designed studies, and employment of some University of Texas mathematics materials followed reviews of these programs. Materials from other installations have been reviewed and used, as indicated in the Materials Developed Elsewhere and the Validation and Evaluation Data sections of this document.

Active participation in the Association for the Development of Instructional Systems (formerly the 1500 users group) and the National Association of Users of Computer Applications to Learning (NAUCAL), an organization of public school users of computer-assisted instruction, has facilitated the exchange of information and materials with other CAI installations. The project hosted the Fall 1970 NAUCAL meeting which included a visit to the MCPS installation with demonstrations of CAI materials developed by MCPS and other installations. Visitations to other installations and correspondence with them also contributed to progress toward this goal.



CAI materials are exchanged and stored on disks.

Objective E

THE DEVELOPMENT OF A DOCUMENT WHICH WILL RELATE THE DETERMINATION AND DEFINITION OF THE APPLICATION OF CAI UTILIZING AN IBM 1500 INSTRUCTIONAL SYSTEM IN THE SCHOOL CLASSROOM SETTING, AND PROJECT THIS APPLICATION TO DETERMINE AND DEFINE THE APPLICATION OF CAI WITHOUT PARTICULAR HARDWARE LIMITATIONS IN THE SCHOOL CLASSROOM SETTING. THIS ACTIVITY WOULD EVALUATE THE VARIOUS CAI INSTRUCTIONAL TECHNIQUES, RELATE THE USE OF THE COMPUTER TO OTHER INSTRUCTIONAL MEDIA, AND DETERMINE THE USE OF THE COMPUTER FOR OTHER ACTIVITIES.

Intent and product of this objective remain the same; however, the objective has been reworded to facilitate understanding:

THE DEVELOPMENT OF A DOCUMENT WHICH WILL DESCRIBE THE APPLICATION OF COMPUTER-ASSISTED INSTRUCTION IN THE SCHOOL SETTING AND WILL EVALUATE VARIOUS CAI TECHNIQUES.

Data collection for this document has been occurring throughout the project's time period and is set forth in the Validation and Evaluation Data and the Cost Analysis sections of this document.

Facility modification was followed by the installation of the computer system with student stations in three different locations. (The IBM 1500 Instructional System is the computer research tool of the project.) Instructional stations, or terminals, vary from location to location; each station consists of some of the following components: cathode ray tube instructional display with light pen, image projector, typewriter, and audio unit.

Modular instructional packages which use a variety of CAI techniques, in combination or on an individual basis, have been developed. The computer is viewed as but one component of a multimedia learning system. Other media are used as a part of some computer-assisted instruction modular packages.

Demonstrations and visitations have continued to occur with hardware designers, manufacturers, services, and users. During Phase III these included representatives of Honeywell, Hewlett-Packard, Computer Communications, and Com-Share.

Additional terminals were added for student use during the evaluation phase. Year-long studies in progress during Phase III included those of physics, Algebra II, and elementary arithmetic at several grade levels. Most of the modular instructional packages were employed in at least one evaluation study. The results of these research efforts are being incorporated in the document fulfilling this objective. Reports on the use of the computer in other roles such as those of record-keeper and diagnostician will also be cited in the publication, and the summer school programs employing CAI materials will be described.

(See the Packages Developed and Materials Developed Elsewhere sections of the Materials Development, Use and Validation chapter of this report for descriptions of the CAI programs used in the evaluation.)

Objective F

THE DESCRIPTION OF THE ROLE OF THE CLASSROOM TEACHER IN THE CAI EQUIPPED SCHOOL SYSTEM AND IDENTIFICATION OF ADDITIONAL SKILLS THIS ROLE WILL REQUIRE.

The role of the teacher in the CAI equipped school may vary according to the number of terminals, their location, types of materials, and implementation strategies. See the Implementation into Curriculum section of the document for a description of this new role.

Terminals at Pleasant View Elementary School are located in a mathematics learning center.

Some student stations in Einstein High School are in a terminal room adjacent to the instructional materials center.

Several different instructional settings were identified for terminal installations. Student stations at Pleasant View Elementary School are located in a mathematics learning center, an individual room set aside solely for this purpose. At Albert Einstein High School there are two terminal locations: a CAI terminal room adjacent to the Instructional Materials Center (IMC) and a mathematics laboratory, an area between two classrooms, set aside for individualized activities of a variety of types. A few terminals were planned for installation in regular classrooms in the junior high school, but the Phase II funding level and the cost of the cable for connection to the computer prohibited testing this environment. (Newport students walk to Einstein and use the IMC terminals.)

As previously specified, varied CAI materials were developed or selected for use. Implementation strategies, too, have been diversified.

A teacher's aide is usually responsible for the students during the period of their CAI experiences which have been planned by a teacher specialist and the classroom teacher.

Documentation of material for the publication describing and specifying the role of the teacher in a CAI equipped school has been an on-going process. The teacher specialists, teachers aides, and involved classroom teachers have contributed observations, insights, and strategies related to the actual employment of the computer as an assistant in the instructional process.

A mathematics laboratory for individualized activities including CAI experiences, is separated from adjacent classrooms at Einstein High School by folding doors.

Objective G

THE PRODUCTION OF "MODULAR INSTRUCTIONAL PACKAGES" FOR USE ON THE IBM 1500 CAI SYSTEM.

More than 50 segments in elementary arithmetic, senior high mathematics, junior high science, and senior high chemistry and physics have been produced. The segments are not considered completed until validation has occurred. Additional segments, involving the subjects cited above and other content such as social studies and elementary language arts, are in various stages of development. (See the Materials Development, Use and Validation chapter for development stages and validation information.)

Geometry students are using CAI assessment tasks to guide their work.

Objective H

THE DESIGN AND DEVELOPMENT OF A PROGRAM TO DETERMINE THE FEASIBILITY OF USING THE IBM 1500 CAI SYSTEM FOR TESTING AND TEST DEVELOPMENT

Testing is one of the basic CAI instructional techniques being investigated as a part of project activities. Test items are imbedded in the modular instructional packages. Pretests on the terminal objectives are written to identify those students who already possess the behaviors and, consequently, do not need instruction. An entering behavior test may be included in a package to assure that students receiving instruction possess the skills and knowledge necessary to begin the segment. Diagnostic testing can determine placement within a module. Instructional test items and criterion test items on enabling objectives are written to determine the path the student follows. Finally, a posttest on the terminal objectives is developed to ascertain whether the package teaches what it purports to teach. Testing is an integral part of the modular instructional packages curriculum development and the evaluation is then included with the package.

Objective H (cont.)

A computer-managed program, Geometry Testing, has been adapted from an MCPS curriculum effort which has been under development for several years. Since 1968, mathematics teachers have been writing behavioral objectives, hierarchies, criterion items and related activities for 10 units in geometry. A mathematics design team consisting of three classroom teachers, released from their classroom responsibilities 10 per cent of the time, have adapted the diagnostic and assessment tasks items for use on the computer.

A pilot test of the first five units was made in the summer of 1970 with 19 students. The program was well received by the students and their teacher. Based on this experience, the decision was made to code the remaining six units. A research study designed to measure the effectiveness of the complete geometry course will be made during 1971-1972 school year. (See Evaluation Design, 1971-1972.)

It was felt that individualization made the use of any standardized midyear examination unfair and impractical, thus a semester examination for the CMI geometry course was prepared. Problems were randomly generated from the assessment task questions, and alternate questions. Each student's examination was matched to his achievement level to date.

In an attempt to further access the computer's capabilities related to large-scale testing, ALTEE was developed. This Algebra II examination allowed each of approximately 350 students to have an individual year-end test.

Two months of part-time work (70 hours) were spent by six teachers of Algebra II at Albert Einstein High School, Kensington, Maryland, preparing the problems for this test. An analysis of problems given on previous examinations by that department revealed need for further resources. An examination of several standardized algebra tests, curriculum guides, and courses of study, provided guidelines for test content. Twenty-five types of problems were identified as measures of Algebra II concepts; four problems of each type were created. This problem bank (100 problems) provided the nucleus for which the test would be generated.

The testing strategy, scoring procedures, and evaluation techniques were developed by the staff of Project REFLECT. For each type of problem, the computer selected randomly one of four alternatives (4^{25} or 1,128,000,000,000,000 uniquely different tests could be created!). The registration procedure identified students by name, teacher, and period number. At the end of 55 minutes of testing, the student, as well as the teacher, received a message indicating the number of problems answered correctly out of 25.

At the end of the testing session (five days averaging five hours a day to test 350 students) each teacher received an additional performance print-out. This evaluation ranked the students in each class from the highest score to the lowest score (designed to ease the assignment of grades). A composite performance listing was also provided, listing the number of students receiving each score, and an analysis of the normal distribution.

Approximately 33 hours were spent coding this examination for computer usage, with an additional eight hours spent on design and strategy.

Objective I

THE DESIGN AND DEVELOPMENT OF A MODEL PLAN FOR INTRODUCTION AND USE OF CAI IN THE PUBLIC SCHOOL ENVIRONMENT.

Documentation of all phases of the project has occurred as the events took place. Planning, facility design and modification, staff orientation and development, materials development, lesson tryouts, validation, instructional use, and evaluation are among the areas documented.

The first annual report, June 1968 to June 1969, together with this document provide the essential information necessary for instituting and implementing CAI in a public school system. Preparation of the model plan has been deferred until June, 1973. During this two-year period, extensive evaluation of the developed curricula will provide the necessary guidelines for the most effective application of these materials.

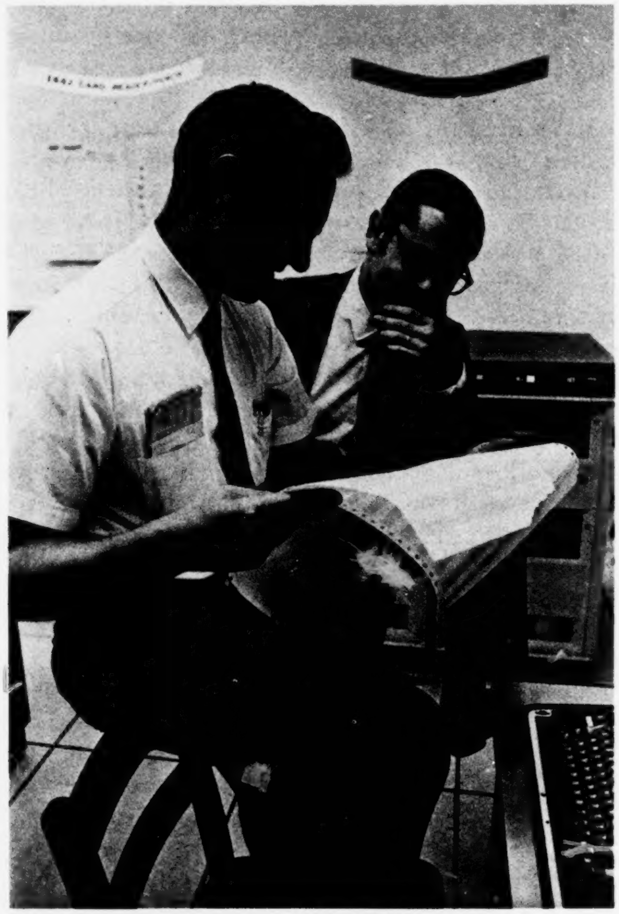
Objective J

CREATION OF THE TECHNICAL UNDERSTANDING REQUIRED TO UTILIZE AND MAINTAIN THE HARDWARE OF THE IBM 1500 CAI SYSTEM.

The systems manager and senior programmer came to the project with previous experience with the IBM 1500 Instructional System. The leasing arrangement with IBM provides for maintenance.

Difficulties with the system have been minimal; downtime (time scheduled for use which had to be postponed because the system was inoperable) has been extremely limited. Most difficulties have been minor and have involved the components of the instructional stations.

Lightning caused some difficulties because of the cable connection between the computer in the high school and the terminals located in the elementary school. IBM engineers installed Transient Voltage Suppressors to eliminate the problems caused by lightning. See the Facility and Technical Operations chapter for a description of this unique problem in a prototype setup and the steps to its solution.



The systems manager observes while an IBM customer engineer examines a printout of a system test.

Objective K

DISSEMINATION OF INFORMATION ON FINDINGS OF THE PROJECT.

Major dissemination efforts during Phases II and III supplemented the previous activities. *The Project REFLECT Annual Report, June, 1968, to June, 1969* and *Authoring Individualized Learning Modules: A Teacher Training Manual* were the principal printed dissemination vehicles.

Orientation discussions, demonstrations, presentations to groups, workshops, magazine articles, flyers on specific topics and participation in associations and conferences were among the other methods used. As the project became more widely known, materials produced by other organizations describing the MCPS CAI activities aided dissemination efforts.

Teachers who were new to the project high school and elementary school staffs received special presentations. Mathematics teachers new to Montgomery County were oriented to CAI as a part of their preservice workshop.

Seminars for more than 20 MCPS summer workshop groups in subject and skill areas were conducted by two supporting teachers assigned to the project for summer 1970. Their efforts were entirely devoted to dissemination. Among the other activities were an all-day seminar for the Metropolitan Washington area public schools and a one-day seminar for area college and university personnel.

Visitors from the school system, other counties, other states, and other nations viewed the project in its activity stages. Some of these visitors were from other Title III projects. During the conventions of the National Science Teachers Association, and the National Council of Teachers of Mathematics, a visit to the MCPS CAI facility was one of the tour offerings. Demonstration of CAI materials developed by MCPS was a feature of the National Association of Users of Computer Applications to Learning Fall 1970 Meeting. The Project REFLECT staff hosted the conference. In addition, many of the presentations featuring project findings were performed by Project REFLECT staff members.

A half-day individualized workshop on behavioral objectives was conducted for 25 teachers of a nearby parochial school. Two weeks later a project-conducted follow-up session checked on their proficiencies.

Presentations and visitations for parent groups, visits by some participants in the White House Conference on Children, and an individualized activity visit for the University of Maryland Program for Administrators in Curriculum Technology (PACT) occurred recently.

Several magazine articles by the teacher specialist in curriculum (science) have appeared in publications whose target populations are science teachers.

Graphic artists at the MCPS central office prepared a three-dimensional display at the request of the project staff. The display on the steps in curriculum development was exhibited at the National Association of Users of Computer Applications to Learning Fall 1970 Conference and the National Science Teachers Association 1971 Convention. Pleasant View Parent-Teachers Association members and MCPS administrators and supervisors were among other viewers.

A multimage with audio presentation on CAI and Project REFLECT was produced by a project staff member. The three-screen presentation was selected for showing in the multimage festival at the Association for Educational and Communications Technology (AECT) 1971 convention. Since its

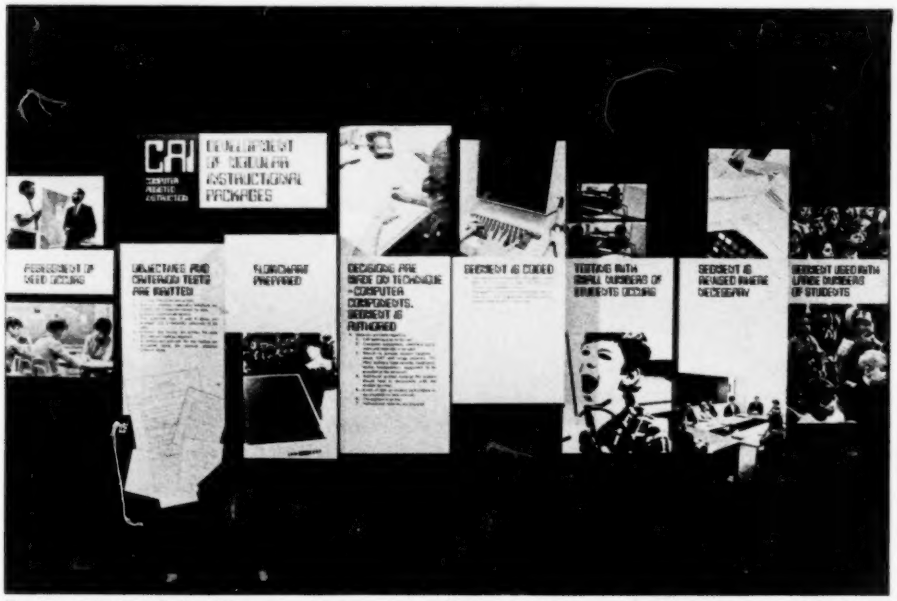
Objective K (cont.)

development this multimage has been used in almost every presentation about the project. Slide-tape presentations on the role of the teacher in a CAI equipped school have also been developed.

"CAI Implementation and Implications" was presented by the former project director at the 1971 American Association of School Administrators convention in Atlantic City. A teacher specialist gave a presentation of the math skills for science program at a 1971 regional meeting of the National Council of Teachers of Mathematics. Another teacher specialist gave two CAI presentations at the 1971 National Science Teachers Convention and a presentation on Project REFLECT and CAI materials demonstration at the 1971 National Society for Programmed Instruction annual meeting. Four members of the project staff with the assistance of University of Maryland PACT group gave presentations with skit illustrations at the AECT 1971 convention. The AECT session was titled "A Mythical School System Adopts CAI." "Install CAI in Your Institution," an individualized half-day workshop at the First Annual Educational Technology Conference, was organized and conducted by the former project director, the acting director, and a teacher specialist. The third general session of "Quality Education Through Innovation," the Maryland State ESEA, Title III Advisory Council State Conference and Public Meeting, was a report on Project REFLECT by the acting projector director.

Staff members also have aided student-directed programs. Sessions on computers in education and computer-assisted instruction conducted by Project REFLECT staff have been part of several schools "free-form" education days.

Dissemination by other organizations has reached additional populations. A Dutch journalist authored a magazine article including information about the project. Crews from the Japanese television network NKH and the British Broadcasting Corporation did on-site filming. North Virginia Educational TV staff members included about five minutes on the project in a series on communication, broadcast six times over WETA-TV; a videotape of this show is housed at the project.


CAI
COMPUTER ASSISTED INSTRUCTION
DEVELOPMENT OF MODULAR INSTRUCTIONAL PACKAGES
ASSESSMENT OF NEED OCCURS
OBJECTIVES AND CRITERION TESTS ARE WRITTEN
FLOWCHART PREPARED
DECISIONS ARE MADE ON TECHNIQUE -COMPUTER COMPONENTS. SEGMENT IS AUTHORED
SEGMENT IS CODED
TESTING WITH SMALL NUMBERS OF STUDENTS OCCURS
SEGMENT IS REVISED WHERE NECESSARY
SEGMENT USED WITH LARGE NUMBERS OF STUDENTS

Engineered to pack for shipment, the steps in curriculum development display was prepared by Gene Uhlmann and Kenneth Petrie of the MCPS graphic arts department.

THE REPORT

This report documents activities of the project for the period June 27, 1969, to June 30, 1971, the project's second and third phases. Among the contents of this document are procedures of Materials Development; Specifics on the Modular Instructional Packages Developed; Implementation of Project REFLECT Materials and Those of Other Installations; Validation and Cost Analysis Data; Procedures for the Installation of Cable from the Einstein Building Computer Room to Pleasant View Elementary School; Montgomery County Public Schools Instructional System and Student Station Configurations; Support Software, and Staff Development Activities and A Resultant Publication, *Authoring Individualized Learning Modules: A Teacher Training Manual.* Observations to date also are included.

Efforts of the first year are summarized in the *Project REFLECT Annual Report, June 1, 1968, to June 26, 1969.* While some of the events of Phase I are included herein as background support information, the reader should consult the first annual report for details on the initial planning, staff orientation, development and training, and setting up of the CAI facility.

Materials, Development, Use and Validation

I. MATERIALS, DEVELOPMENT, USE AND VALIDATION

A. DEVELOPMENT PROCEDURES

Philosophy

Inherent in all aspects of Project REFLECT materials development is the philosophy of the staff regarding educational and instructional technologies, individualized instruction, and the systems approach to education.

In an individualized instructional setting, each student progresses at his own rate through learning experiences tailored to his own needs, interests, and learning style, thereby optimizing the likelihood of his attainment of specific objectives. The implications of this philosophy for CAI materials development include (1) the need for diagnostic activities for establishing levels of achievement and skill development; (2) provision for the student and teacher to select specific behavioral objectives for the student with consideration given to the student's needs and interests as well as his performance on the diagnostic activities; (3) use of a variety of materials, response modes, and activities; (4) opportunities for the student to work at his own rate; and (5) the necessity to provide assessment tasks which measure the student's progress by comparing his performance with *his* specific objectives.

Among the working areas available for students in individualized mathematics programs is the mathematics laboratory.

Modular instructional packages, consisting of computer-assisted instruction programs with associated equipment and materials for experiences leading to the attainment of specific behavioral objectives, are basically of a single concept type. No attempt has been made to develop entire units or courses or to fill specific time allocations. Segments designed employ a variety of the presently known CAI techniques of drill and practice, simulation, remote computing, testing, tutorial dialogue, and combinations of these. Some segments include attempts to extend these techniques and develop new ones. Modular instructional packages with strategies for various student target populations, including some which feature learner control of sequence and duration, have been developed. Data collected from the use of validated segments is being used in identification of the role of computer-assisted instruction in an individualized learning system.

Mrs. Morgan helps a student in the Math Skills for Science individualized summer program identify CAI segments which will aid him.

In keeping with principles of instructional technology, curricular materials are designed, implemented, and evaluated systematically in terms of specific objectives. Segments are developed in accordance with findings of learning and communications research. Other instructional materials are used in conjunction with many of the modular instructional packages. Identification of the role of CAI in instruction and the role of the teacher in the CAI-equipped school are two curriculum related project goals which should contribute to the design of effective learning systems.

With learner attainment of specific objectives as a goal, the instructional system becomes learner-centered. A scientific integration designed to maximize the learning for the individual student incorporates the various components of the total instructional process: equipment, procedures, facilities, personnel, etc.. Necessary features include feed-back and other evaluations as well as a variety of media and personnel resources. In such a system the teacher is manager, counselor, tutor, coach, and instructor.

In this project, computer-assisted instruction is not regarded as a total self-contained learning system; but rather it is considered but one component of a more comprehensive, individualized multimedia learning system design. Determination of the role of CAI within that system: where, with whom, by what technique, and in what context can computer-assisted instruction improve the learning process in a large public school system is one major task of the project. Computer-assisted instruction, as used in this project, is the utilization of remote time-shared computer terminals to assist the teacher in assuring student progress toward the attainment of specific learning objectives through the individualization of the instructional process.

Personnel

Experienced classroom teachers (teacher specialists and other design team members) develop and adapt materials for use in the Montgomery County Public Schools Computer-Assisted Instruction Project. Senior high chemistry and physics materials are developed by a teacher specialist. The elementary school, junior high science, and senior high mathematics design teams are each composed of three or four supporting teachers available to the project 10 per cent of their time and a full-time teacher specialist who, in addition to performing other special functions within the project, provides leadership to the design team, coordinates efforts in his subject field, and authors materials individually. Design teams for social studies and foreign language also develop materials. Responsibilities of design team members include identifying areas for development of CAI materials, producing CAI modular instructional packages, and examining and evaluating (and adapting, where necessary) for Montgomery County Public Schools use CAI materials produced at other installations.

Three teacher specialists were employed in August, 1968, and were trained initially by the project director. (Another teacher specialist employed during Phase I was released from the project in June, 1969, because of budget limitations.) Two additional teacher specialists participated in a training course designed by the staff for supporting teachers. All five teacher specialists continuing with the project during

After a segment is authored by design team members, a programmer enters the material in the computer system.

Phase II were classroom teachers immediately prior to joining the staff. One of these teacher specialists was appointed an administrative intern in a secondary school July 1, 1970; his CAI staff development specialist job was not filled during Phase III. When the promotion of the project director occurred and the teacher specialist in curriculum (mathematics) was named acting project director, a mathematics design team member was appointed February 1, 1971, to the teacher specialist in mathematics position. The supporting teacher training program was his preparation; evidence of its effectiveness was his assumption of the teacher specialist responsibilities without additional training.

Three groups of supporting teachers, the 10 per cent staff members who are currently classroom teachers, were oriented and trained by the project staff. See the Staff Development chapter for a description of the training document which includes materials produced and used in three supporting teacher training courses and which features individualized activities.

During the second year of the project, 16 supporting teachers and five teacher specialists worked in the production of CAI materials. Primary areas of development were elementary school arithmetic, junior high school science, senior high school science (physics and chemistry), and senior high school mathematics. Other areas of effort were elementary school language arts, junior high school social studies, and first-year French. During Phase III, four teacher specialists and seven supporting teachers were involved in curriculum-related efforts; some design team members planned research studies.

Vital to the development procedures are personnel responsible for converting the authored materials into machine-usable form. Four full-time programmers, three of whom had completed computer school, received COURSEWRITER II training under the direction of the systems manager and senior programmer. Initial training occurred in January, 1969, just prior to installation of the computer system in the high school. Within two weeks of their employment, these programmers were coding modular instructional packages. Three of these programmers left the project; two had changes in residence, and one left to take a programming job with a private firm.

Since the principal emphasis of the second phase of the project was materials development, part-time employees were hired to assist with coding materials. Three college students, two with computer science background and one with no previous work experience in the computer field, worked part time. They learned COURSEWRITER II on the job. During Phase III, one high school junior joined the programming staff on a part-time basis. For most of that phase, the programming staff consisted of two full-time employees – a senior programmer and a junior programmer – and four part-time programmers.

In the curriculum development procedures section of this chapter, the specific steps performed by authors and programmers are identified.

Objectives Relating to Materials Development

The original project proposal cited as an objective "Determination of the role of CAI in implementing the Montgomery County grades K-12 curriculum designs in science, mathematics, English language arts, social studies, and foreign languages by:

a) The identification, within the total grades K-12 curriculum designs, of instructional elements appropriate for implementation by CAI,

b) Assessment of the applicability of CAI materials produced outside the school system for implementing the program of instruction of the Montgomery County Public Schools,

c) Production of a limited number of "modular instructional packages" for use in CAI set-up, programmed for flexibility in mode of presentation to meet the needs of individual learners within the overall curriculum design of the Montgomery County Public Schools,* and

d) Actual participation by students in the use of CAI equipment and materials as part of the curriculum."

Other objectives in the proposal included "determination of the feasibility of using CAI facilities for testing and test development" and "determination, through systematic research, of a) relative efficiency and effectiveness of CAI in the learning process and b) use of CAI in diagnosing the developmental status of learners and their needs."

Project objectives were restated in measurable terms to facilitate the processes of project management and evaluation as a part of the development of the Master Plan, the first activity of Phase I. The project director, through the development of the Master Plan, provided a means of properly planning the activities to insure that the objectives are accomplished in accordance with the proposal, that all components of the project are given adequate and proper attention, and that proper evaluation of the project is achieved. Content, purpose, and intent of the original objectives cited in the project proposal to the United States Office of Education remain unchanged; the more explicit, measurable statements of objectives related to materials development follow:

The development of an evaluation document which will review and evaluate existing CAI materials that are available and adaptable to public school use on the IBM 1500 Instructional System.

The development of a document which will describe the application of computer-assisted instruction in the school setting and will evaluate various CAI techniques.

The production of "Modular Instructional Packages" for use on the IBM 1500 CAI system.

The design and development of a program to determine the feasibility of using the IBM 1500 CAI system for testing and test development.

With the IBM 1500 Instructional System, these terminal devices may be used for student stations.

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*As available CAI materials were reviewed and evaluated and the lack of available, suitable materials became evident, project efforts moved from production of a limited number to production of a greater number of modular instructional packages.

Curriculum Development Procedures

The curriculum development subplan, prepared by Mrs. Catherine E. Morgan, teacher specialist in curriculum at that time, formally documented the means and procedures to be utilized by the project staff to develop CAI materials for use in the project. This subplan identified the roles and responsibilities of each member of the curriculum development team and cited procedures for choosing, developing, and evaluating CAI materials for use in the Montgomery County Public Schools project. Portions of the curriculum development subplan which are directly related to review, selection, and adaptation of materials developed at other installations are cited in the section "Materials Developed Elsewhere."

Criteria for choice of the specific units to be developed were specified in the subplan:

1. Module will lend itself to using CAI techniques.

2. Materials will be developed which may require a variety of approaches for individual student needs such as differences in

   a) Vocabulary levels
   b) Modes of learning
   c) Rates of learning
   d) Degrees of challenge
   e) Interests
   f) Entering behaviors

3. Consideration will be given to developing some units for which

   a) Detailed item analysis will be useful to the teacher
   b) Diagnostic tests can be written
   c) Drill and practice exercises can be developed

Guidelines for development of lesson segments specified the steps to be performed and ordered their occurrence:

1. Assessment of need occurs.

2. Terminal objectives(s) are written.

3. Minimum entering measurable behaviors are written with criterion test item(s) for each.

4. Enabling objectives are written.

5. The objectives from 2 and 4 above are arranged into a hierarchy presumed to be valid.

6. Criterion test item(s) are written for each terminal and enabling objective.

7. A pretest and posttest for the module are prepared, using the terminal objective criterion items.

8. A flowchart for the instructional strategy to be used is prepared.

9. Decisions are made regarding:
    a) CAI technique(s) to be used
    b) Computer components and additional equipment and materials to be used
    c) Stimuli to activate student response – visual (CRT and image projector, TV, film), auditory (tape recorder, earphones), tactile (manipulatory equipment to be provided at the terminal)
    d) Additional printed material the student should have in conjunction with the student terminal
    e) Kinds of data on student performance to be accumulated for later analysis
10. The segment is written.
11. Instructional materials are prepared.
12. The segment is coded.
13. The segment is functionally debugged so that there are no errors in logic and the course "flows" as intended by the author.
14. The segment is reviewed by the author. At this time any errors in grammar, spelling, and/or subject material will be corrected.
15. The segment is tested with a small number of students. Student reactions are collected.
16. The segment is revised, where necessary.
17. The segment is used with larger numbers of students for validation.

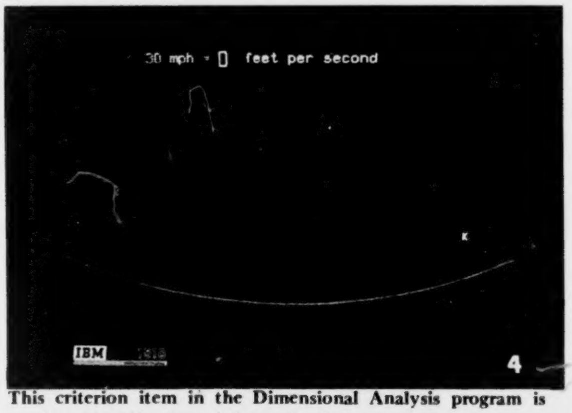
Design team members performed the steps preceding coding (steps 1 to 11). The IBM 1500 Instructional System and the COURSEWRITER II languages were topics treated in the training course so that the authors could attain a working knowledge of the capabilities and limitations of the system and the languages. (See Chapter IV, Staff Development, for additional information on the training programs.) The COURSEWRITER II coding was performed by programmers, who also did the initial check for lesson flow. The designers then continued the development. APL programming was usually carried out by the author.

Topics selected for development were based on the needs of the target population. Students, teachers, and curriculum supervisors provided suggestions and comments which were vital factors in the decision-making process. A special factor in some topics identified for development was the adaptability to specific CAI techniques or strategies.

Specific statements of what the learner would do at the end of the learning experience (the terminal objectives) were written. Each terminal objective stated what the performance of the learner would be, the conditions under which he would carry out the performance, and the criteria to be used to determine if the learner had achieved the minimum acceptable performance.

Analysis of each terminal objective resulted in identification of the component tasks. An entry level was specified; minimum entering behaviors were stated. The entering behaviors are those essential to the acquisition of the new behaviors, the prerequisites for progress toward the objective. Criterion items for each entering behavior were written. Testing the entering behaviors considered essential to acquiring new behaviors helps prevent subsequent student failure. Enabling objectives, the subordinate behaviors necessary between the entering behaviors and the terminal objectives, were identified. Enabling objectives and entering behaviors are written in measurable behavioral form. Arrangement of the terminal and enabling objectives into a learning dependency sequence (a hierarchy) was the next step. In practice, the development steps relating to enabling objectives, entering behaviors, and the hierarchy were intermingled and occurred almost at the same time.

Criterion items were written for each terminal and enabling objective. Usually at least two items were written for each objective. The items testing enabling behaviors were used within the segment to identify the point at which an individual should enter an instructional sequence or to ascertain the student preparedness to proceed within the learning sequence. One or more items for each terminal objective were assembled into a pretest; and different items, at least one for each terminal objective, were combined into a posttest. Pretests on material to be presented preclude the possibility that a student will be subjected to instruction on behaviors already learned. Posttests are used to identify learners who have attained the segment objectives. Data from pretest and posttest use is employed in the identification of the validity of the modular instructional package – Does it teach what it purports to teach?

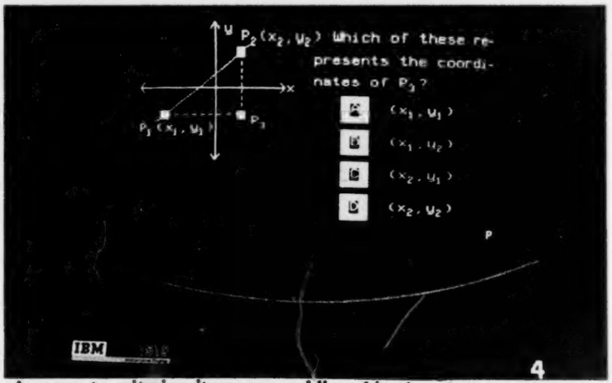

30 mph = ▯ feet per second

This criterion item in the Dimensional Analysis program is used in identification of the student's entry point.

The instructional strategy to be used was selected or designed, and a graphic description (a flowchart) was prepared to depict the order of events and relationships of component steps. The instructional strategy specifies the sequence of instruction, the conditions which may modify the lesson flow, and any options available to the individual student.

Decisions were made regarding the CAI techniques to be employed, the terminal devices and other media to be used to communicate relevant material, and the information to be collected. Activities based on the objectives in their dependency relationship (the hierarchy) are designed.

Using the hierarchy, the instructional strategy flowchart, and the criterion items on the enabling objectives as guides, the author wrote the lesson segment and prepared, or specified needed preparation of, additional instructional materials.


Which of these represents the coordinates of P_3?

A (x₁, y₁)
B (x₁, y₂)
C (x₂, y₁)
D (x₂, y₂)

Answers to criterion items on enabling objectives, imbedded in instruction, determine the next sequence to be presented.

An author uses display guides to indicate desired placement of material on the screen.

Material to appear on the cathode ray tube of the instructional display was sketched in its desired position on a planning guide for COURSEWRITER II coding. A student assistant graphic artist prepared illustrations for flipbook use.

Coding of the segment was performed by instructional programmers, who also did the preliminary checking for the flow intended by the author. The author then reviewed the completed modular instructional package. Spelling, grammatical and subject matter errors were corrected.

Several students, members of the target population, tested the segment. The students gave their reactions. Performance data was collected and observations were made during this trial run. If necessary the segment was revised with the essential production steps repeated, and then a retesting occurred.

A student reacts to a modular instructional package during small-scale student testing.

Records of student performance are recorded sequentially on tape.

When the segment was deemed ready for use, student members of the target population who did not possess the terminal behaviors on which the lesson was structured used the segment. Performance data on this group, which usually consisted of 30 or more students, was used to determine if the modular instructional package was valid. Validated packages were used in the comparative evaluations during Phase III.

B. MODULAR INSTRUCTIONAL PACKAGES DEVELOPED – DESCRIPTION OF THE DESIGN TEAMS AND MATERIALS PRODUCED

Materials produced at Project REFLECT are described in the following sections. Each area of primary effort – elementary school subjects, junior high school science, senior high school mathematics, and senior high school chemistry and physics – has a section on materials produced at the Montgomery County Public Schools project. Modular instructional packages in social studies, French, and other subjects that are not in the areas of primary effort are described in a category titled "Other Subject Matter Areas."

Adaptations of materials developed at other installations are depicted in "Materials Developed Elsewhere." Use of materials and validation data are reported in specific sections on those topics.

At the beginning of each of the subject matter sections, the backgrounds of the persons designing and authoring the computer-assisted instruction segments are presented. NONE OF THE PERSONS AUTHORING MODULAR INSTRUCTIONAL PACKAGES AT THE PROJECT HAD ANY CAI EXPERIENCES BEFORE THEIR PROJECT WORK. See the *Project REFLECT Annual Report, June, 1968, to June, 1969,* and the Staff Development Chapter of this document for descriptions of their preparations.

Vacancies in teacher specialist positions in the Montgomery County Public Schools are advertised in *The Superintendent's Bulletin,* an inhouse publication distributed to the entire staff. Interested persons make application to the Department of Professional Personnel, interviews are conducted, and the person to fill the job is identified. The teacher specialists on the staff are full-time employees who serve as design team leaders.

1. ELEMENTARY SCHOOL SUBJECTS

by

Beverly J. Sangston

The Design Team

a. Operation Whole Numbers

b. Project Perimeter

c. Learning About Per Cents

d. Word Search

e. Expanding Numerals

f. Sign-on Fractions

35

THE DESIGN TEAM

Led by an experienced elementary school classroom teacher, who is a full-time project employee, five elementary teachers worked one day every other week developing modular instructional packages for project use.

The teacher specialist who guides the design team, Miss Beverly Sangston, joined the staff in February, 1969. During Phase II approximately 90 per cent of Miss Sangston's working time was devoted to curriculum development efforts. Curriculum related tasks absorbed 95 per cent of her time during Phase III. Five and one half years of teaching second and fifth graders preceded her CAI work. Miss Sangston holds a B.A. in sociology from Mary Washington College and has additional credits in elementary counseling and elementary school methods. Other experiences which may be related to her success as a CAI author include working in review and evaluation of mathematics materials, teaching review math in summer school, supervising student teachers, and using individualized reading in her second grade class for one year. Miss Sangston was trained on the job; part of her preparation for CAI authoring was received with the second group of supporting teachers, but most of it was acquired in an informal manner with guidance from other CAI staff members. Miss Sangston's preparation also included a one-week workshop on behavioral objectives sponsored by the Maryland State Department of Education.

The supporting teachers, after experiencing the training course on materials development, designed and authored lesson segments. One summer 1969 workshop participant was invited to be a supporting teacher.

In October, 1968, two teachers at the elementary school involved in the project and a teacher at a school with a similar population were identified by their principals to be participants in the first training group. Another Montgomery County Public Schools elementary teacher, identified by CAI staff members involved with the design team, completed the training course but because of a change in assignment near the end of the sessions was unable to join the design team.

Representatives from the parochial schools and the private schools organization were trained with the second group; this participation was to help determine the further involvement of the nonpublic schools. The private schools representative found it personally difficult to attend the full-day training sessions and dropped out before the end of the course. On completion of the training course, the parochial schools representative wished to continue participation and was invited to join the elementary design team.

Since the training of the classroom teachers began at different times, their program contributions to the project are of differing durations, varying from two years to only ten months.

Pleasant View Elementary School, one of the three project schools, had two teacher representatives in the earliest training group conducted for the classroom teachers who work 10 per cent of their time with the project staff. Miss Ann Cummins and Mrs. Jean Murdock completed the training course, joined the design team, and co-authored a CAI modular instructional package.

Work in early childhood education characterizes Miss Ann Cummins' background. She holds a B.S. degree and has additional credits in early childhood education, special education, and audio-visual methods. At the time she joined the project staff (on a part-time basis), she had three years of teaching experience, all at the first grade level.

Mrs. Jean Murdock came to the project with 12 years teaching experience; for six years she taught first grade; four years, third grade; one year, fourth grade; and one year, fifth grade. Mrs. Murdock's undergraduate work was at Wilson Teacher's College; she received a B.S. degree with primary education as her major. Graduate work at The George Washington University, The American University, and the University of Maryland also preceded her CAI work. She had been a participant in a summer mathematics workshop. After completing the course for supporting teachers, she co-authored a mathematics modular instructional package during Phase II.

The principal of a school with a student population similar to that of Pleasant View Elementary identified a school-based resource teacher to participate in the initial training group. Mrs. Nita Axley of Highland Elementary School had 17 years teaching experience when she was selected for the design team, Her. B.A. degree from the University of Wisconsin was with a double major – psychology and sociology. An M.Ed. degree from the University of Maryland and 30 hours of work beyond the master's degree were concentrated in the fields of elementary education and teaching English to speakers of other languages. She had taught teachers in county mathematics workshops. Following the CAI preparation, she designed and authored the segment on Expanding Numerals. Mrs. Axley did not rejoin the project during Phase III.

When the second group of trainees was selected, a teacher who had interviewed for the teacher specialist in elementary school subjects position was identified by CAI staff members to join the course. After completing the training program, she did not join the design team and author materials because her school assignment had changed and she wished to devote her efforts to her new position.

Orientation to computer-assisted instruction and subsequent preparation for developing segments compatible with CAI and the project goals were provided 20 additional persons who constituted a workshop group in the summer of 1969. When the aforementioned vacancy occurred in the design team, one of the workshop participants was asked by the teacher specialist leader to join the design team. Miss Donna Kirsch, who holds a B.A. degree from Mary Manse College, Toledo, Ohio, majored in elementary education. Her minor was social studies. She has 11 years teaching experience at the fourth and sixth grade levels. Participation in two county-sponsored mathematics workshops and methods and content courses in reading, science, and mathematics preceded her enrollment in the CAI workshop. Miss Kirsch authored the CAI mathematics program, Learning About Per Cents.

Sister Mary Adele White of Saint Martin's School, Gaithersburg, Maryland, a parochial school representative, trained with the second group. Selected by the Archdiocese of Washington Office of Education, Sister Mary Adele had twenty-one years teaching experience at the first, second and third grade levels. She earned her B.S. degree in elementary education with an English major from Trinity

College and also studied religious education at La Salle College. Prior to joining the design team, Sister Mary Adele had participated in workshops in primary education and gerontology. She had used individualized instruction in her classroom and employed programmed instruction materials. After her training she joined the design team and authored a language arts modular instructional package, Word Search.

One of the spin-offs of the project has been the effect of the training course on the persons involved. The participants have indicated changes in their teaching that are a direct result of their project participation. The individual elementary design team members indicated that (1) "(I) organized whole new thinking patterns as a result of flowcharting"; (2) "(I have) changed thought processes (and) think through plans more clearly"; (3) "When children had difficulties, (I) reevaluated my techniques and made sure steps were small enough"; and (4) "Probably (I am) more conscious of apparent blocks that occur in the learning process."

U A R D
FRACTIONS
OPERATION WHOLE NUMBERS
CAI

a. OPERATION WHOLE NUMBERS (OWN)

Need

Teachers in the elementary school wanted a program that could be used on a widespread basis, so the first program developed by the design team was a diagnostic testing and drill and practice program in basic operations involving whole numbers. Other reasons for its selection were the development of a program that would reach a range of student ages and provide diagnostic information for the teachers. The program was designed for fifth and sixth grade target populations but has also been found useful at the third and fourth grades, in Adult Basic Education and for remediation with junior and senior high school students. See the validation section for reports on its use.

Description

Operation Whole Numbers combines the CAI techniques of diagnostic testing and drill and practice. There are a variety of use modes for the program. Specific drills may be selected for the student by the classroom teacher; the student may select drills he wishes to experience; or the author-arranged program of diagnostic test, automatic placement, and drill sequence may occur.

In the most commonly used mode, that of diagnosis preceding drill, the needs of each student are identified on entry into the program through a series of survey and diagnostic tests. Drills are provided for practice on a specific mathematical concept and its related skill. There are no tutorial sections in the program; the classroom teacher provides the instruction. The program written in COURSEWRITER II is designed to build proficiency. The student works at an IBM 1510 Instructional Display with light pen. The segment was designed and authored by Beverly J. Sangston; Catherine E. Morgan served as a consultant, and Chris Eshleman coded the program.

The content of Operation Whole Numbers is divided into four sections, a unit for each of the four operations. Each section within the program has the following components:

1. A pretest consisting of a survey test on the terminal objective and a network of diagnostic tests to place the student at the appropriate level for drill or instruction.

2. A sequence of drills designed to provide practice in a computational skill based on a specific mathematical concept.

At the completion of the four survey tests, the drill sequences, or a combination thereof, the student is presented a posttest. This test measures performance on the terminal behaviors with the problems randomly presented.

Terminal Objectives

1. Given 3 three-place numerals presented vertically, the student constructs the sum when regrouping is required in ones, tens, and hundreds places.

2. Given a subtraction algorism presented vertically, the student subtracts a four-place numeral from another four-place numeral; regrouping is required in hundreds, tens, and ones places.

3. Given a multiplication algorism of a three-place factor and a two-place factor presented vertically, the student constructs the product; regrouping is required.

4. The student constructs the quotient and remainder for any two-place divisor and four-place dividend.

For each of these objectives, four problems must be successfully completed; the maximum number of questions presented is five.

Entering Behaviors

To enter the Operation Whole Numbers Program, a student is identified by the classroom teacher. Since drill and practice programs are designed to build proficiency in a skill, the concrete and symbolic experiences necessary to understand the concept related to that skill are all provided in the classroom prior to CAI experience.

Drill in the basic number facts with sums to 9 is the lowest level to which a student in this program can be branched following diagnosis. See the hierarchy of behaviors for the entering behaviors necessary for the other levels of addition.

The author-arranged program is designed so that the student proceeds through the addition levels before entering the subtraction drills. The lowest level of subtraction drills is again the basic number fact level.

The diagnostic-drill arranged program orders the student's procedure in the program in a sequential manner from the lowest identified level in addition, subtraction, multiplication, or division. Diagnosis is based on the learning dependency arangements, the hierarchies.

(Entering behaviors for division are indicated before the enabling objectives for that operation.)

ADDITION

Enabling Objectives

For each objective mastery consists of an attainment of at least nine of the ten problems presented.

Level 1 Given an addition problem presented horizontally or vertically with two numbers whose sum is less than or equal to 9, the student constructs the sum.

Examples: $3 + 4 =$

$$\begin{array}{r} 5 \\ \underline{+2} \end{array}$$

Level 2 Given an addition problem presented horizontally or vertically with three 1-place numerals whose sum is less than or equal to 9, the student constructs the sum.

Examples: $3 + 3 + 2 =$

$$\begin{array}{r} 1 \\ 6 \\ \underline{+2} \end{array}$$

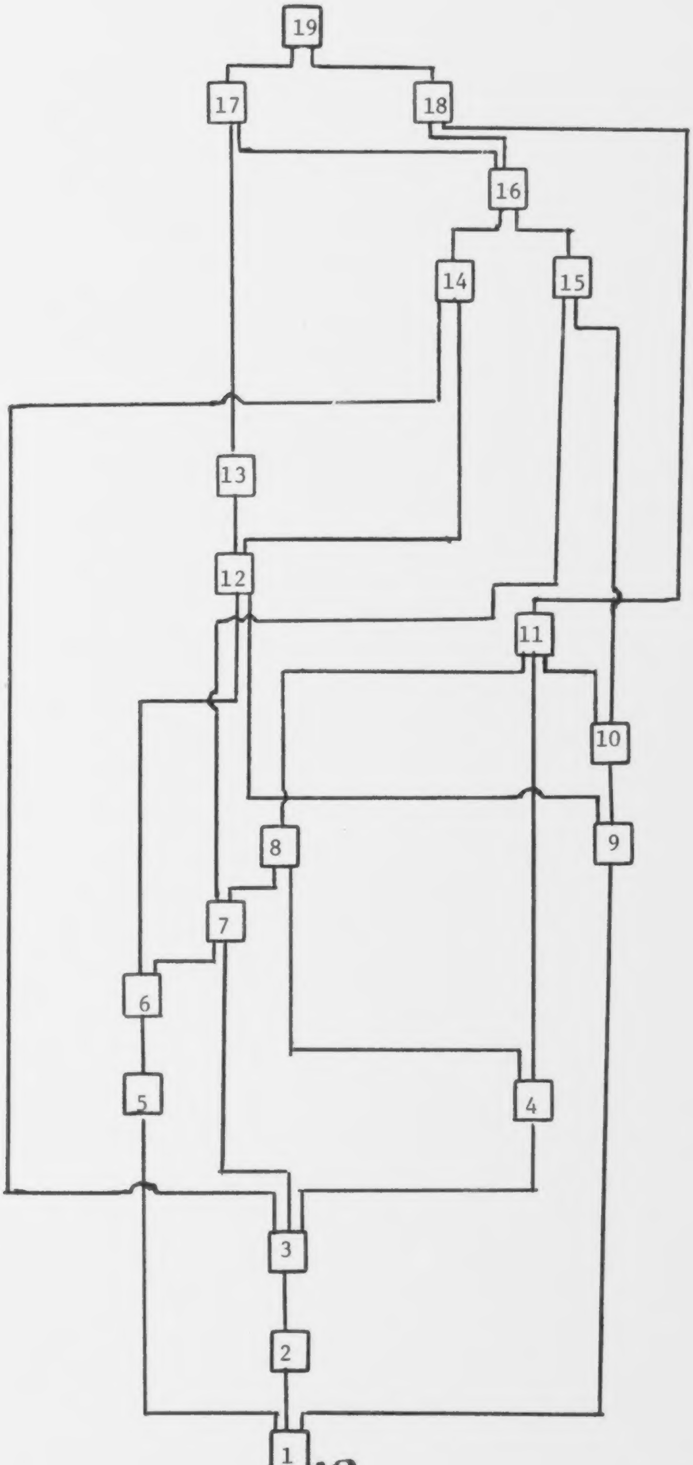
Level 3 Given an addition problem presented horizontally or vertically with two multiples of ten whose sum is less than or equal to 90, the student constructs the sum.

Examples: $40 + 20 =$

$$\begin{array}{r} 50 \\ \underline{+10} \end{array}$$

OPERATION WHOLE NUMBERS

ADDITION HIERARCHY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Level 4 Given an addition problem presented horizontally or vertically with two multiples of one hundred whose sum is less than or equal to 900, the student constructs the sum.

Examples: 600 + 100 = $\begin{array}{r}700\\ +200\\ \hline\end{array}$

Level 5 Given an addition problem presented horizontally or vertically with a multiple of ten and a 1-place numeral, the student constructs the sum.

Examples: $\begin{array}{r}10\\ +6\\ \hline\end{array}$ 30 + 8 =

Level 6 Given an addition problem presented horizontally or vertically with a 2-place numeral and a 1-place numeral, the student constructs the sum, no regrouping required.

Examples: $\begin{array}{r}23\\ +4\\ \hline\end{array}$ 36 + 2 =

Level 7 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum, no regrouping required.

Example: $\begin{array}{r}71\\ +16\\ \hline\end{array}$

Level 8 Given an addition problem with two 3-place numerals presented vertically, the student constructs the sum, no regrouping required.

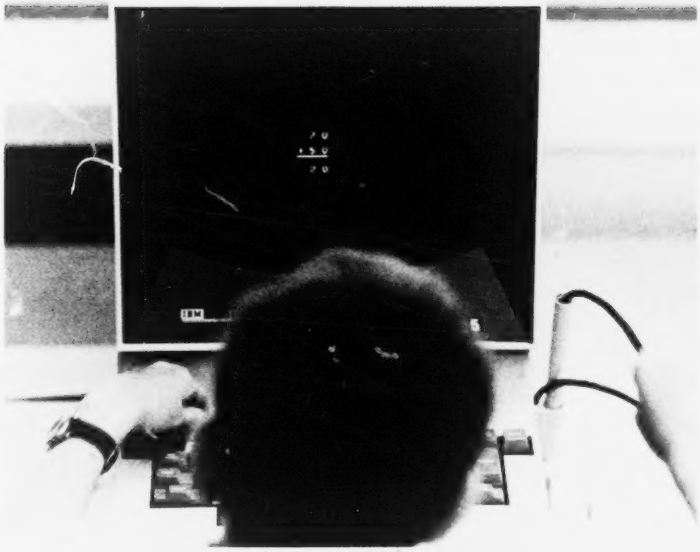
Example: $\begin{array}{r}246\\ +523\\ \hline\end{array}$

Level 9 Given an addition problem presented horizontally or vertically with two numbers whose sum is less than or equal to 18, the student constructs the sum.

Examples: 11 + 7 = $\begin{array}{r}9\\ +9\\ \hline\end{array}$

Level 10 Given an addition problem presented horizontally or vertically with two multiples of ten whose sum is less than or equal to 180, the student constructs the sum.

Examples: $\begin{array}{r}80\\ +60\\ \hline\end{array}$ 90 + 20 =



Level 11 Given an addition problem presented horizontally or vertically with two multiples of one hundred whose sum is less than or equal to 1800, the student constructs the sum.

Examples: 900 + 900 =

$$\begin{array}{r} 700 \\ \underline{+600} \end{array}$$

Level 12 Given an addition problem presented horizontally or vertically with a 2-place and a 1-place numeral, the student constructs the sum, regrouping from ones to tens required.

Examples: 34 + 7 =

$$\begin{array}{r} 29 \\ \underline{+6} \end{array}$$

Level 13 Given addition problem presented horizontally or vertically with three 1-place numerals, the student constructs the sum.

Examples: 9 + 9 + 9 =

$$\begin{array}{r} 5 \\ 6 \\ \underline{+4} \end{array}$$

Level 14 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum, regrouping from ones to tens required.

Example:

$$\begin{array}{r} 18 \\ \underline{+49} \end{array}$$

Level 15 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum, regrouping from tens to hundreds required.

Example:

$$\begin{array}{r} 95 \\ \underline{+34} \end{array}$$

Level 16 Given an addition problem with two 2-place numerals presented vertically, the student constructs the sum, regrouping in ones and tens places required.

Example:
$$\begin{array}{r} 96 \\ \underline{+48} \end{array}$$

Level 17 Given an addition problem with three 2-place numerals presented vertically, the student constructs the sum, regrouping in ones and tens places required.

Example:
$$\begin{array}{r} 94 \\ 25 \\ \underline{+48} \end{array}$$

Level 18 Given an addition problem with two 3-place numerals presented vertically, the student constructs the sum, regrouping in ones, tens, and hundreds places required.

Example:
$$\begin{array}{r} 684 \\ \underline{+937} \end{array}$$

Level 19 Given an addition problem with three 3-place numerals presented vertically, the student constructs the sum, regrouping in ones, tens, and hundreds places required.

Example:
$$\begin{array}{r} 986 \\ 747 \\ \underline{+568} \end{array}$$

SUBTRACTION

Enabling Objectives

For each objective 10 items are presented, the student must score at least nine.

Level 1 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of 9 or less.

Examples: $\begin{array}{r} 8 \\ \underline{-4} \end{array}$ 7 - 6 =

Level 2 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of ten.

Examples: 10 - 6 = $\begin{array}{r} 10 \\ \underline{-4} \end{array}$

Level 3 Given a subtraction problem presented horizontally or vertically, the student subtracts a multiple of ten from a sum of 90 or less.

Examples: $\begin{array}{r} 70 \\ \underline{-30} \end{array}$ 40 - 20 =

Level 4 Given a subtraction problem presented horizontally or vertically, the student subtracts a multiple of one hundred from a sum of 900 or less.

Examples: $\begin{array}{r} 600 \\ \underline{-200} \end{array}$ 700 - 500 =

Level 5 Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a two-place numeral; regrouping is not required.

Examples: $\begin{array}{r} 65 \\ \underline{-4} \end{array}$ 76 - 2 =

Level 6 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a two-place numeral; no regrouping is required.

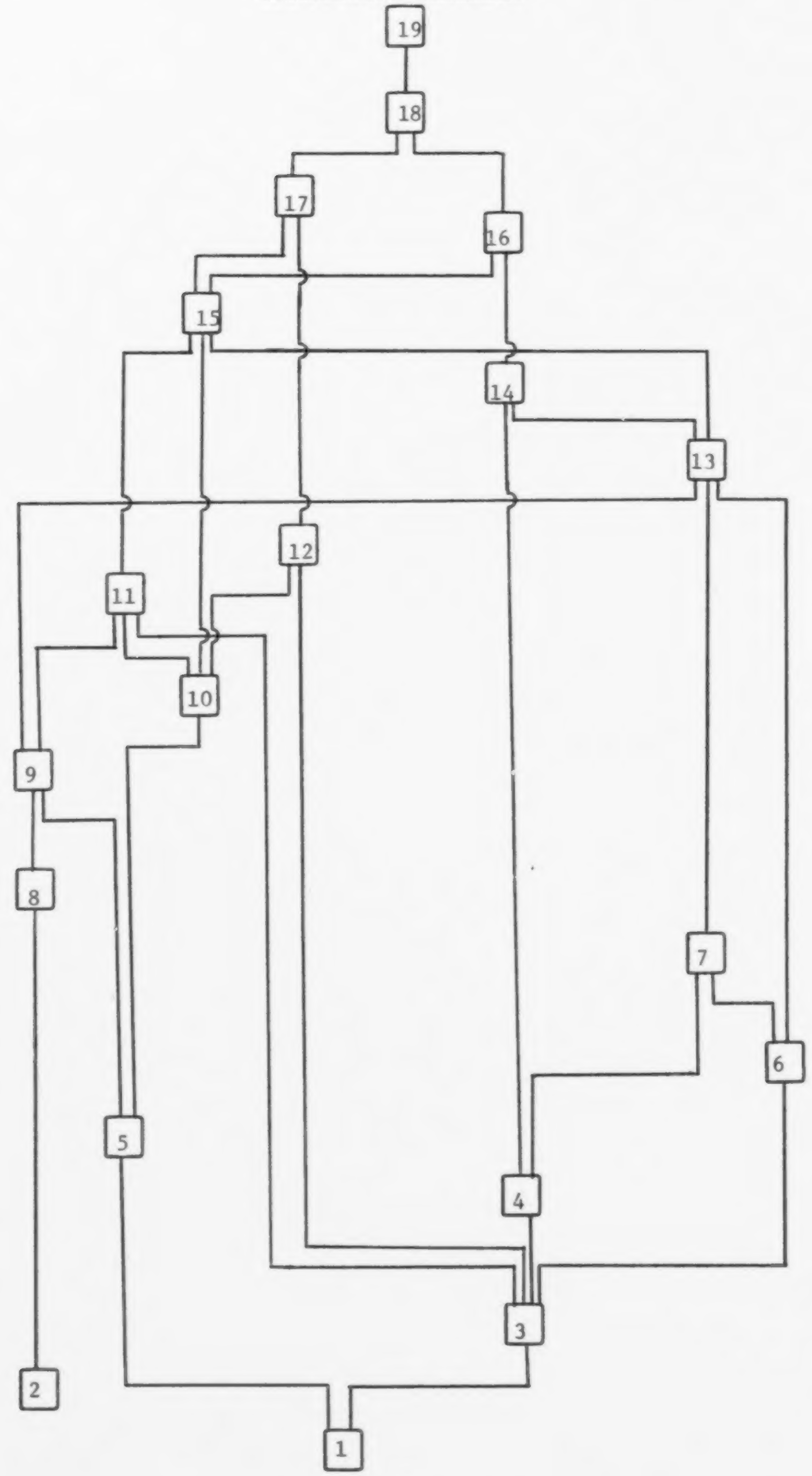
Example: $\begin{array}{r} 86 \\ \underline{-53} \end{array}$

Level 7 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping is not required.

Example: $\begin{array}{r} 789 \\ \underline{-456} \end{array}$

OPERATION WHOLE NUMBERS

SUBTRACTION HIERARCHY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Level 8 Given a subtraction problem presented horizontally or vertically, the student subtracts a number from a sum of 18 or less.

Examples: 18 17 - 12 =
-9

Level 9 Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a two-place numeral greater than 20 and not a multiple of ten; regrouping from tens to ones is required.

Examples: 24 36 - 9 =
-7

Level 10 Given a subtraction problem presented horizontally or vertically, the student subtracts a one-place numeral from a multiple of ten; regrouping from tens to ones is required.

Examples: 30 20 - 6 =
-8

Level 11 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a two-place numeral; regrouping from tens to ones is required.

Example: 38
-19

Level 12 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a multiple of ten; regrouping from tens to ones is required.

Example: 40
-13

Level 13 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a three-place numeral; regrouping from hundreds to tens is required.

Example: 367
-94

Level 14 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping from hundreds to tens is required.

Example: 725
-591

Level 15 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a three-place numeral; regrouping from hundreds to tens *and* tens to ones is required. No zeros appear in the given problem.

Examples: 324 214
-96 -96

Level 16 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a three-place numeral; regrouping from hundreds to tens *and* from tens to ones is required. No zeros appear in tens place in the given problem.

Examples: $\begin{array}{r}846\\ \underline{-357}\end{array}$ $\qquad$ $\begin{array}{r}716\\ \underline{-357}\end{array}$

Level 17 Given a subtraction problem presented vertically, the student subtracts a two-place numeral from a multiple of one hundred; regrouping from hundreds to tens *and* from tens to ones is required.

Example: $\begin{array}{r}500\\ \underline{-56}\end{array}$

Level 18 Given a subtraction problem presented vertically, the student subtracts a three-place numeral from a four-place numeral; regrouping in hundreds, tens, *and* ones is required.

Examples: $\begin{array}{r}1{,}432\\ \underline{-654}\end{array}$ $\qquad$ $\begin{array}{r}4{,}000\\ \underline{-567}\end{array}$

Level 19 Given a subtraction problem presented vertically, the student subtracts a four-place numeral from a four-place numeral; regrouping in hundreds, tens, *and* ones is required.

Examples: $\begin{array}{r}9{,}284\\ \underline{-7{,}995}\end{array}$ $\qquad$ $\begin{array}{r}9{,}000\\ \underline{-7{,}995}\end{array}$

As Phase III ends, the subtraction hierarchy is undergoing minor revisions; the need for the inclusion of additional levels was indicated through an analysis of student performance records.

MULTIPLICATION

Enabling Objectives

For each enabling objective mastery consists of an attainment of at least nine of the ten problems presented.

Level 1 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from zero to five and a factor which is a number from zero to nine.

Examples: 4 x 5 = 4
x5

Level 2 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from zero to five and a factor which is a multiple of ten.

Examples: 4 x 50 = 50 x 4 = 50
x4

Level 3 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from zero to five and a factor which is a multiple of one hundred.

Examples: 4 x 500 = 200 x 3 = 200
x3

Level 4 Given a multiplication problem presented vertically, the student constructs the product without regrouping; the factors are a two-place numeral and a one-place numeral from one to five.

Examples: 12 11
x4 x5

Level 5 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from six to nine and a factor which is a number from zero to nine.

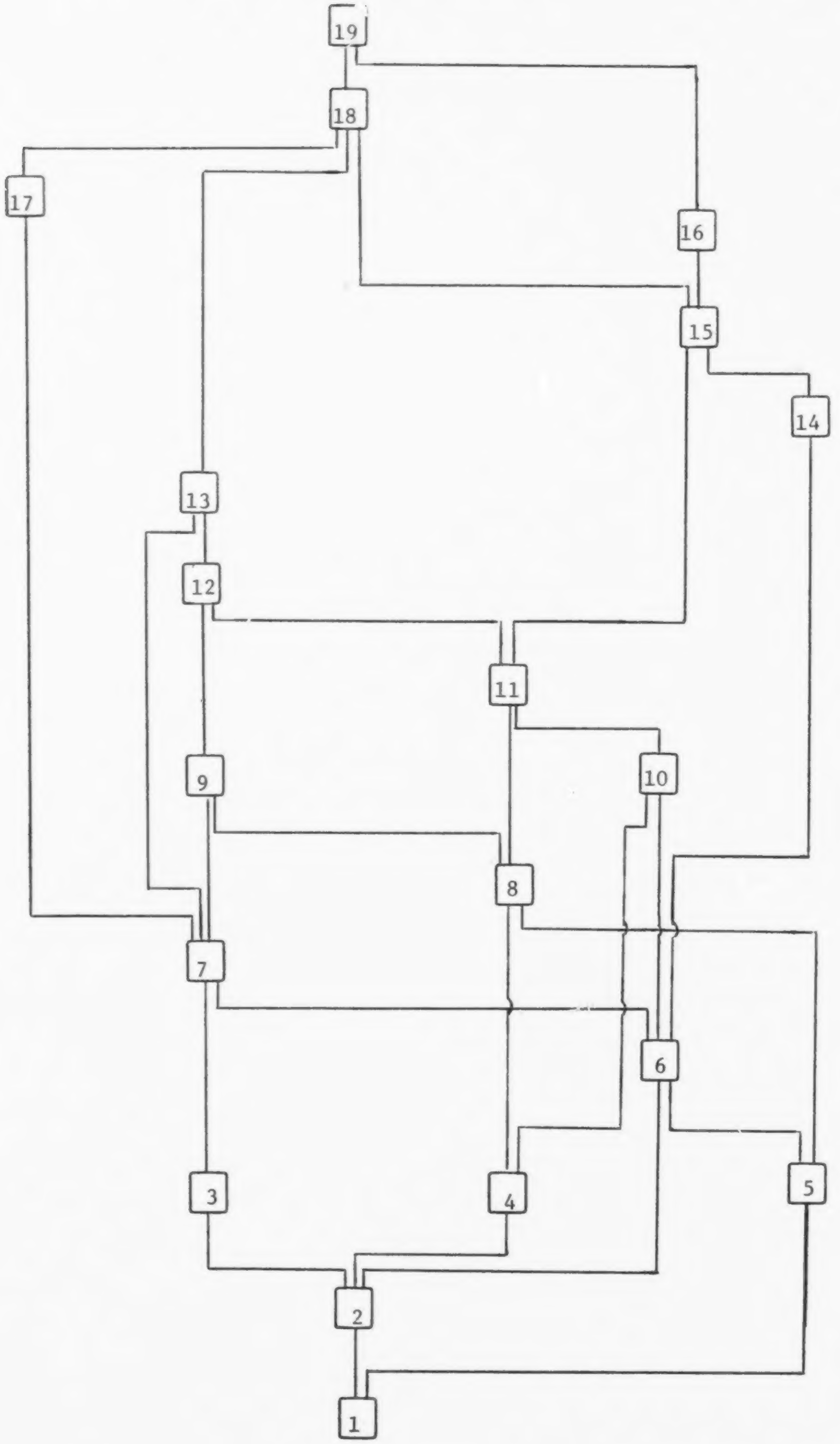
Examples: 6 x 7 = 6
x7

Level 6 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from six to nine and a factor which is a multiple of ten.

Examples: 6 x 70 = 70 x 6 = 90
x8

OPERATION WHOLE NUMBERS

MULTIPLICATION HIERARCHY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Level 7 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a number from six to nine and a factor which is a multiple of one hundred.

Examples: 6 x 700 = 700 x 7 = $\begin{array}{r} 700 \\ \text{x}6 \\ \hline \end{array}$

Level 8 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a two-place numeral and a factor which is a one-place numeral; regrouping is required from ones to tens place.

Examples: $\begin{array}{r} 13 \\ \text{x}5 \\ \hline \end{array}$ $\begin{array}{r} 24 \\ \text{x}4 \\ \hline \end{array}$

Level 9 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a three-place numeral and a factor which is a one-place numeral; regrouping is required from ones to tens place.

Examples: $\begin{array}{r} 118 \\ \text{x}2 \\ \hline \end{array}$ $\begin{array}{r} 123 \\ \text{x}4 \\ \hline \end{array}$

Level 10 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a two-place numeral and a factor which is a one-place numeral; regrouping is required in tens place.

Examples: $\begin{array}{r} 72 \\ \text{x}4 \\ \hline \end{array}$ $\begin{array}{r} 41 \\ \text{x}5 \\ \hline \end{array}$

Level 11 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a two-place numeral and a factor which is a one-place numeral; regrouping is required in ones *and* tens place.

Examples: $\begin{array}{r} 37 \\ \text{x}8 \\ \hline \end{array}$ $\begin{array}{r} 49 \\ \text{x}5 \\ \hline \end{array}$

Level 12 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a three-place numeral and a factor which is a one-place numeral; regrouping is required in ones *and* tens place.

Examples: $\begin{array}{r} 154 \\ \text{x}5 \\ \hline \end{array}$ $\begin{array}{r} 167 \\ \text{x}2 \\ \hline \end{array}$

Level 13 Given a multiplication problem presented vertically, the student constructs the product of factor which is a three-place numeral and factor which is a one-place numeral; regrouping is required in ones, tens, *and* hundreds place.

Examples: $\begin{array}{r} 293 \\ \text{x}6 \\ \hline \end{array}$ $\begin{array}{r} 425 \\ \text{x}7 \\ \hline \end{array}$

Level 14 Given a multiplication problem presented horizontally or vertically, the student constructs the product of two factors, each of which is a multiple of ten.

Examples: 20 x 30 = 40
x60

Level 15 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a two-place numeral and a factor which is a multiple of ten; regrouping is required from tens to hundreds place.

Examples: 29 73
x30 x80

Level 16 Given a multiplication problem presented vertically, the student constructs the product of two factors each of which is a two-place numeral; regrouping is required.

Examples: 29 38
x64 x45

Level 17 Given a multiplication problem presented horizontally or vertically, the student constructs the product of a factor which is a multiple of one hundred and a factor which is a multiple of ten.

Examples: 700 x 30 = 40 x 600 = 800
x50

Level 18 Given a multiplication problem presented vertically, the student constructs the product of a factor which is a three-place numeral and a factor which is a multiple of ten; regrouping is required.

Examples: 725 612
x30 x80

Level 19 Given a multiplication problem presented vertically, the student constructs the product of factor which is a three-place numeral and a factor which is a two-place numeral; regrouping is required.

Examples: 763 894
x25 x36

DIVISION

Entering Behaviors

A. Student constructs the product of the basic multiplication facts (1 x 1 through 5 x 9).

B. Student applies the principle: division is the inverse operation of multiplication.

Enabling Objectives

Level 1 Given a divisor from one to five and a dividend which is a multiple of the divisor, the student constructs the one-place quotient.

Examples: $15 \div 5 =$ $4\overline{)16}$

Level 2 Given a divisor from two to five and a dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Examples: $7 \div 2 =$ $4\overline{)18}$

Level 3 Given a divisor from one to five and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the quotient.

Examples: $3\overline{)36}$ $4\overline{)48}$

Level 4 Given a divisor from two to five and a dividend which is not a multiple of ten or a multiple of the divisor, the student constructs the two-place quotient and the remainder.

Examples: $2\overline{)49}$ $4\overline{)87}$

Level 5 Given a divisor from two to five and a dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the two-place quotient when the tens digit in the dividend is *not* evenly divisible by the divisor.

Examples: $4\overline{)64}$ $5\overline{)85}$

Level 6 Given a divisor from two to five and a three-place dividend which is not a multiple of ten but is a multiple of the divisor, the student constructs the two-place quotient.

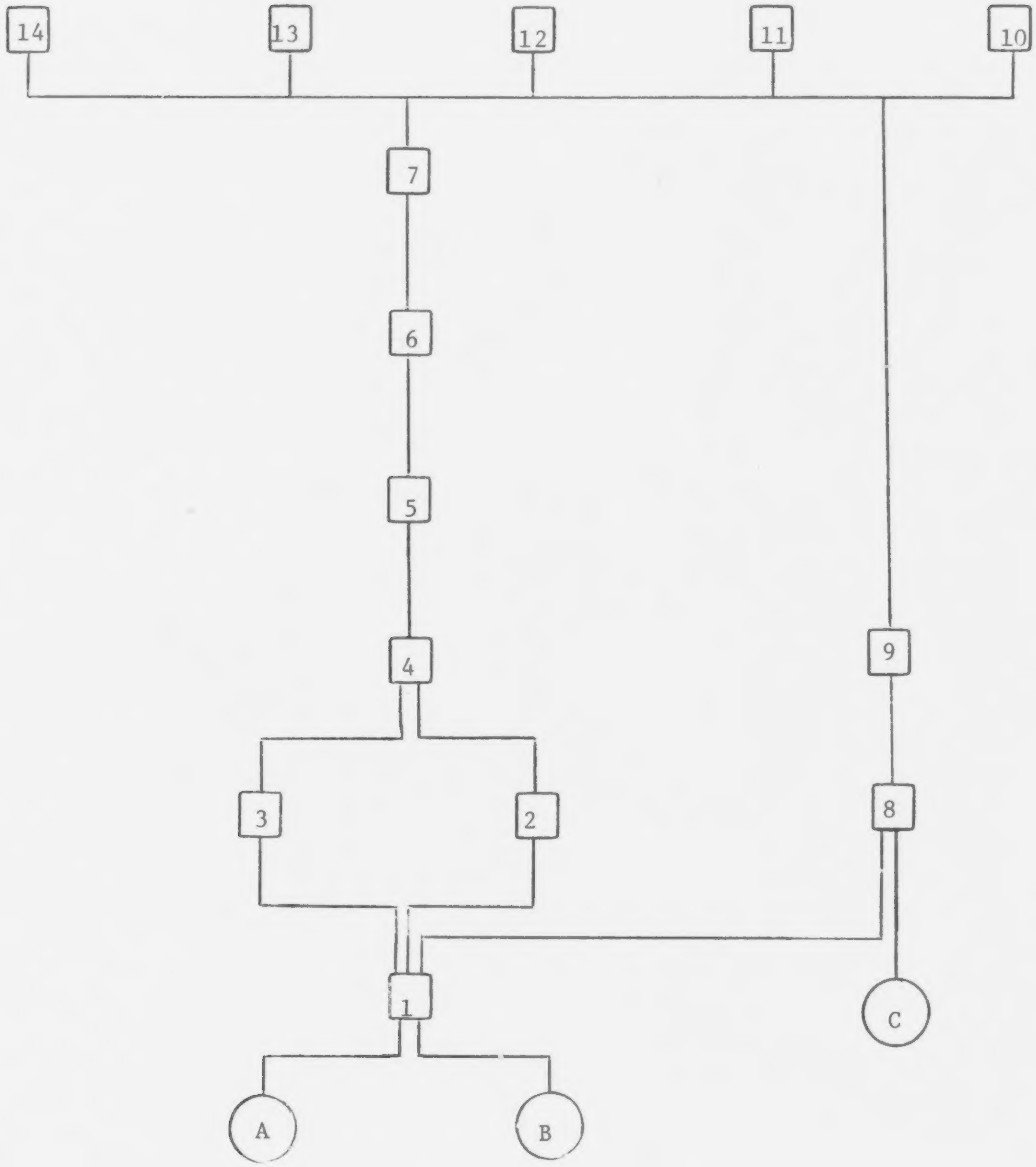
Examples: $4\overline{)248}$ $5\overline{)355}$

Level 7 Given a divisor from two to five and a three-place dividend which is *not* a multiple of ten but is a multiple of the divisor, the student constructs the two-place quotient when the hundreds and tens digit in the dividend is *not* evenly divisible by the divisor.

Example: $4\overline{)264}$

OPERATION WHOLE NUMBERS

DIVISION HIERARCHY OF ONE-PLACE DIVISORS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Given a divisor from two to five and a three-place dividend which is *not* a multiple of ten or a multiple of the divisor, the student constructs the two-place quotient and the remainder.

Example: $2\overline{)157}$

Entering Behavior

C. Student constructs the product of the basic multiplication facts (5 x 9 through 9 x 9).

Enabling Objectives

Level 8 Given a divisor from six to nine and a dividend which is a multiple of the divisor, the student constructs the one-place quotient.

Examples: $81 \div 9 =$ $9\overline{)54}$

Level 9 Given a divisor from six to nine and a dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Examples: $9\overline{)73}$ $6\overline{)37}$

Level 10 Given a divisor from six to nine and a three-place dividend which is *not* a multiple of ten or a multiple of the divisor, the student constructs the two-place quotient and the remainder.

Examples: $8\overline{)246}$ $6\overline{)428}$

Level 11 Given a one-place divisor and a three-place dividend which is a multiple of the divisor, the student constructs the three-place quotient with a zero in tens place.

Examples: $2\overline{)802}$ $7\overline{)707}$

Level 12 Given a one-place divisor and a three-place dividend which is *not* a multiple of the divisor, the student constructs the three-place quotient and the remainder.

Examples: $4\overline{)905}$ $5\overline{)904}$

Given a one-place divisor and a three-place dividend which is *not* a multiple of the divisor, the student constructs a three-place quotient with a zero in the tens place and a remainder.

Examples: $3\overline{)604}$ $5\overline{)508}$

Level 13 Given a one-place divisor and a three-place dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Example: $2\overline{)820}$

Given a one-place divisor and three-place dividend which is a multiple of ten but *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $8\overline{)350}$

Level 14 Given a one-place divisor and a three-place dividend which is not a multiple of ten or a multiple of the divisor, the student constructs the quotient and the remainder.

Examples: $8\overline{)764}$ $\qquad$ $2\overline{)653}$

Entering Behavior

D. Student completes the enabling objectives with one-place divisors.

Enabling Objectives

Level 15 Given a divisor which is a multiple of ten and a dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Examples: $80 \div 20 =$ $\qquad$ $30\overline{)90}$

Level 16 Given a divisor which is a multiple of ten and a three-place dividend which is a mutliple of the divisor, the student constructs the quotient.

Examples: $480 \div 80 =$ $\qquad$ $120 \div 20 =$

Level 17 Given a divisor which is a multiple of ten and a three-place dividend which is a multiple of ten and a multiple of the divisor, the student constructs the quotient.

Example: $20\overline{)480}$

Given a divisor which is a multiple of ten and a three-place dividend which is *not* a multiple of ten or a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $10\overline{)245}$

Level 18 Given a two-place divisor and a two-place dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Examples: $27\overline{)83}$ $\qquad$ $19\overline{)98}$

Level 19 Given a two-place divisor and a three-place dividend which is a multiple of the divisor, the student constructs the two-place quotient.

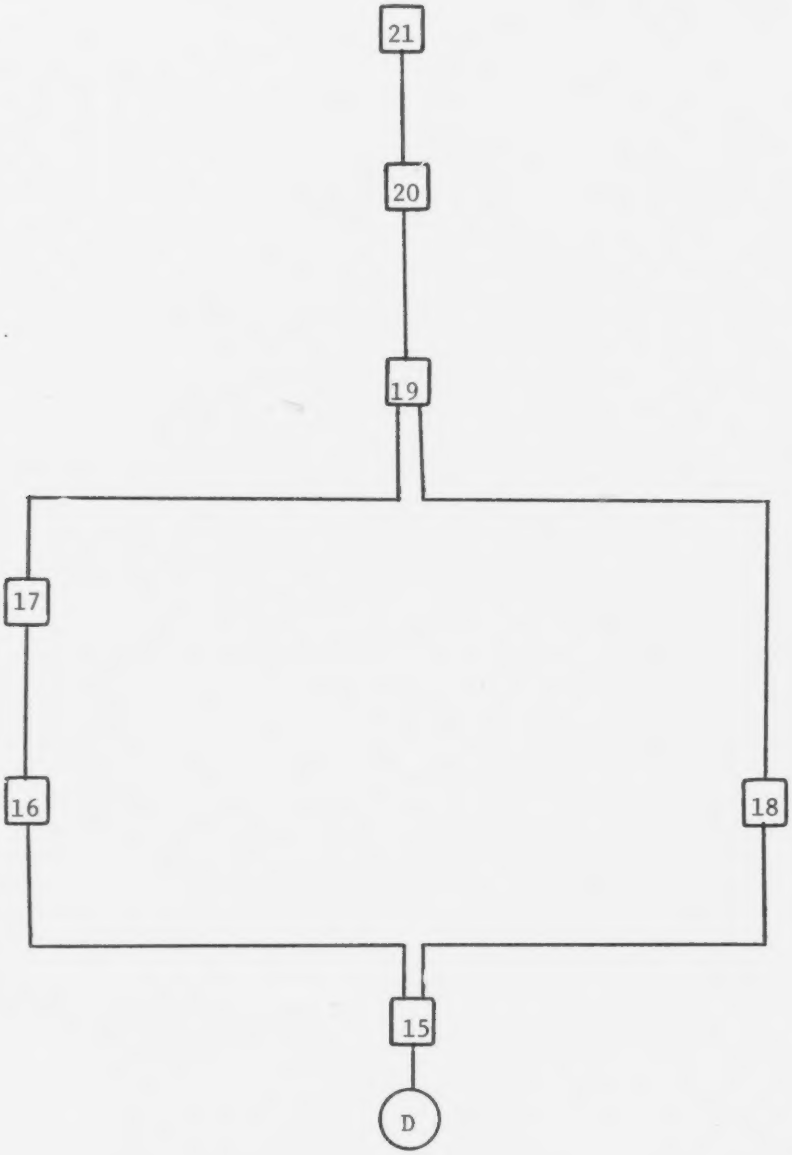
Example: $52\overline{)936}$

Given a two-place divisor and a three-place dividend which is *not* a multiple of the divisor, the student constructs the two-place quotient and the remainder.

Example: $13\overline{)885}$

OPERATION WHOLE NUMBERS

DIVISION HIERARCHY OF TWO-PLACE DIVISORS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Level 20 Given a two-place divisor and a three-place dividend which is a multiple of the divisor, the student constructs the one-place quotient.

Example: $56\overline{)\,280}$

Given a two-place divisor and a three-place dividend which is *not* a multiple of the divisor, the student constructs the one-place quotient and the remainder.

Example: $38\overline{)\,261}$

Level 21 Given a two-place divisor and a four-place dividend which is a multiple of the divisor, the student constructs the quotient.

Example: $27\overline{)\,1539}$

Given a two-place divisor and a four-place dividend which is *not* a multiple of the divisor, the student constructs the quotient and the remainder.

Example: $76\overline{)\,9645}$

As Phase III ends, the division hierarchy is undergoing revision.

An analysis of student performance records indicated the need for major changes in the program. These changes will involve the inclusion of new skill areas and additional drill levels.

Pretest

For each operation (addition, subtraction, multiplication, and division) the pretest consists of a maximum of five problems, four of which must be correct. The strategy is illustrated under flowcharts.

Posttest

Criterion items on the terminal objectives have been grouped to form the posttest. Sample questions follow:

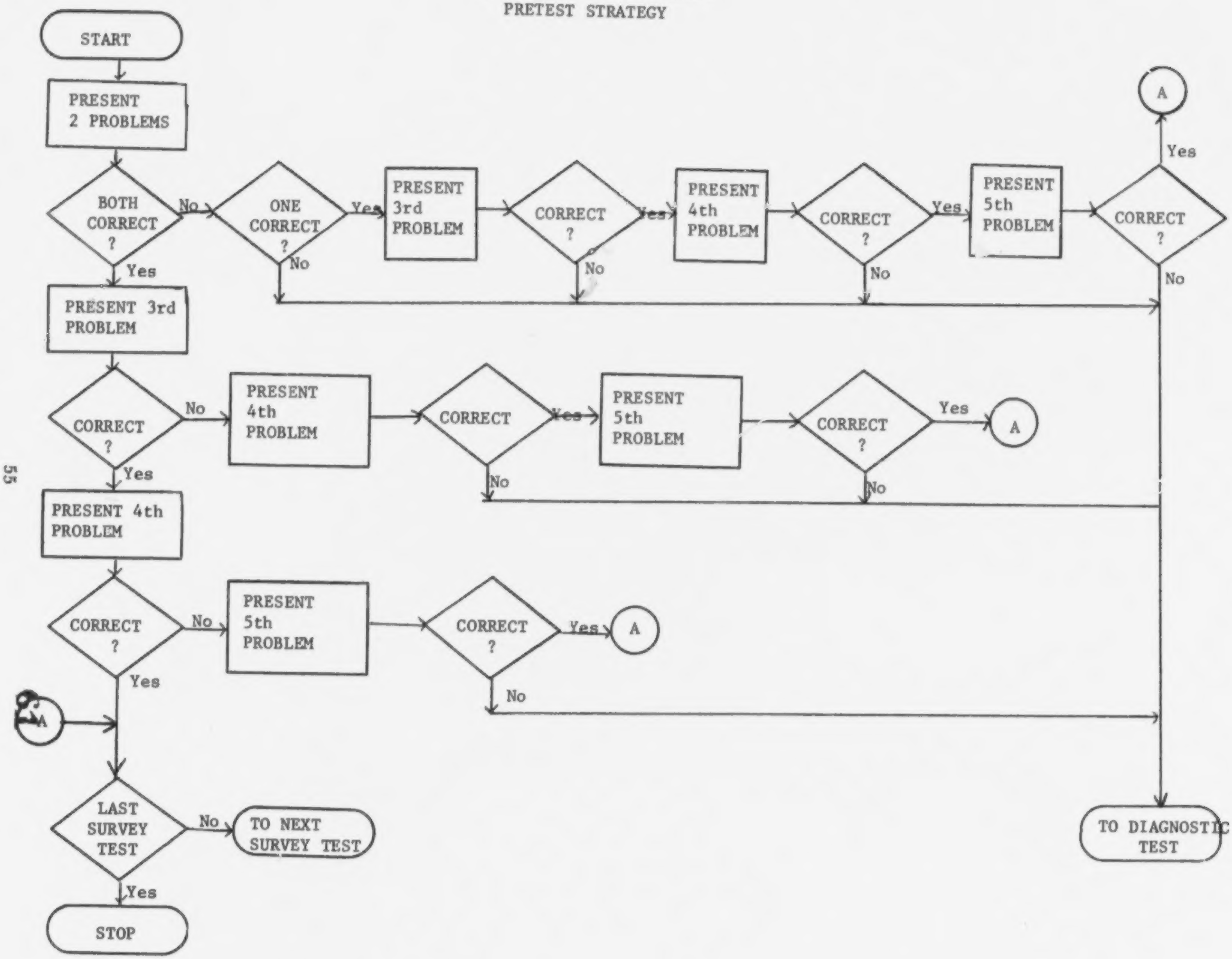
476 853 +289	879 643 +587	327 854 +631
7804 −2939	9006 −3867	4627 −1978
368 x84	367 x48	925 x27
$46\overline{)7834}$	$85\overline{)2693}$	$53\overline{)6247}$

Three items for each operation are presented in random order. Criterion for success is 100 per cent attainment.

Flowcharts

Included here are the flowcharts for the author-arranged program pretest and diagnostic test, and the drill strategy for *all* use modes. The strategies are similar for the other operations—subtraction, multiplication, and division.

OPERATION WHOLE NUMBERS
PRETEST STRATEGY


START
PRESENT 2 PROBLEMS
BOTH CORRECT ?
No
Yes
ONE CORRECT ?
Yes
No
PRESENT 3rd PROBLEM
CORRECT ?
Yes
No
PRESENT 4th PROBLEM
CORRECT ?
Yes
No
PRESENT 5th PROBLEM
CORRECT ?
Yes
No
A
PRESENT 3rd PROBLEM
CORRECT ?
No
Yes
PRESENT 4th PROBLEM
CORRECT
Yes
No
PRESENT 5th PROBLEM
CORRECT ?
Yes
No
A
PRESENT 4th PROBLEM
CORRECT ?
No
Yes
PRESENT 5th PROBLEM
CORRECT ?
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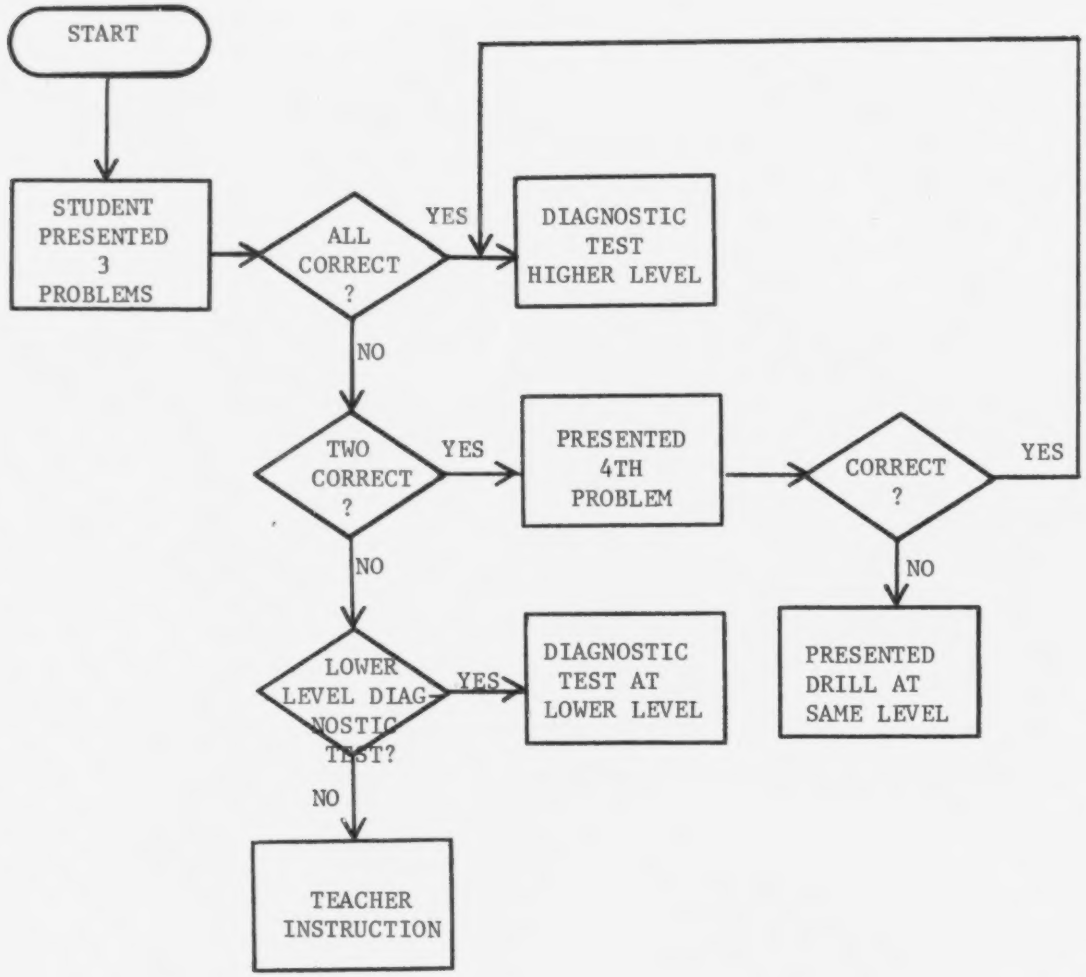
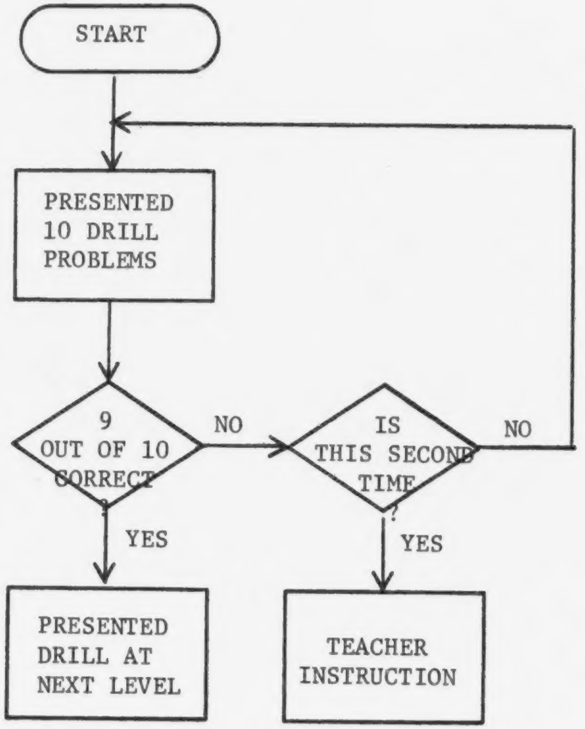
LAST SURVEY TEST
No
Yes
TO NEXT SURVEY TEST
STOP
TO DIAGNOSTIC TEST

ADDITION DIAGNOSTIC TEST STRATEGY

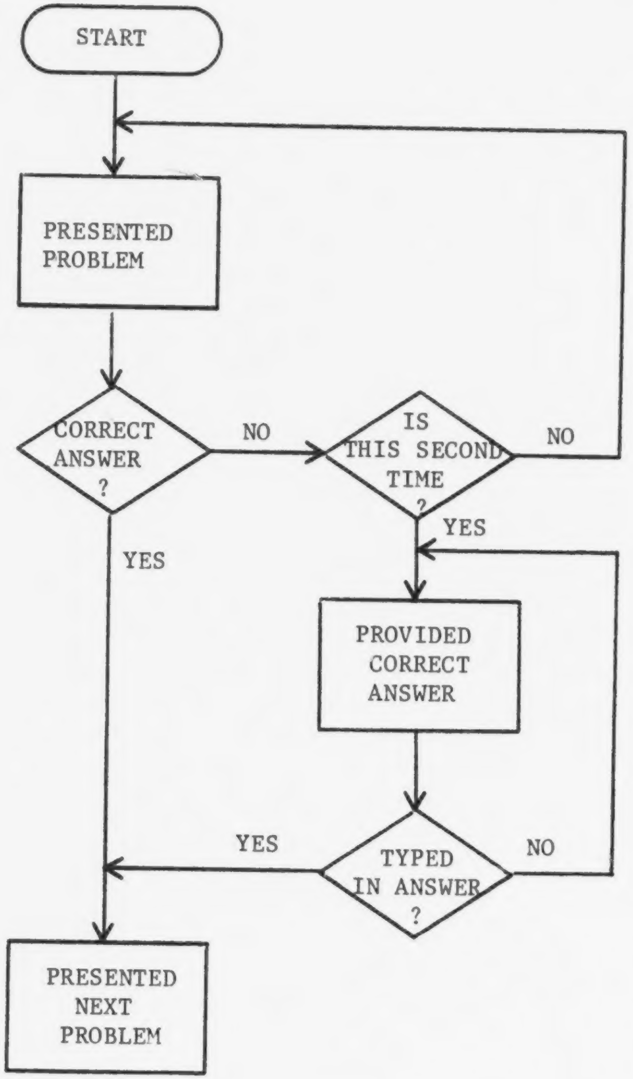

START
STUDENT PRESENTED 3 PROBLEMS
ALL CORRECT ?
YES
DIAGNOSTIC TEST HIGHER LEVEL
NO
TWO CORRECT ?
YES
PRESENTED 4TH PROBLEM
CORRECT ?
YES
NO
PRESENTED DRILL AT SAME LEVEL
NO
LOWER LEVEL DIAGNOSTIC TEST?
YES
DIAGNOSTIC TEST AT LOWER LEVEL
NO
TEACHER INSTRUCTION

OPERATION WHOLE NUMBERS

DRILL STRATEGY


START
PRESENTED 10 DRILL PROBLEMS
9 OUT OF 10 CORRECT ?
NO
YES
PRESENTED DRILL AT NEXT LEVEL
IS THIS SECOND TIME ?
NO
YES
TEACHER INSTRUCTION

PROBLEM STRATEGY

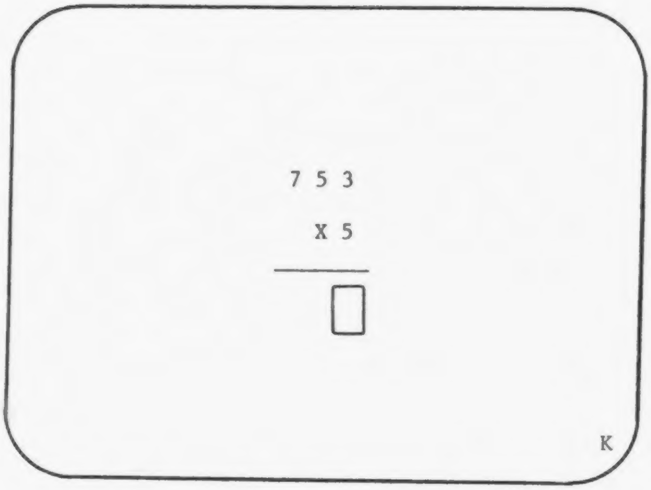

START
PRESENTED PROBLEM
CORRECT ANSWER ?
NO
YES
IS THIS SECOND TIME ?
NO
YES
PROVIDED CORRECT ANSWER
TYPED IN ANSWER ?
YES
NO
PRESENTED NEXT PROBLEM

Mode of Presentation

The student works at a cathode ray tube type terminal with keyboard and light pen. Instructions related to the operation of the terminal are provided. The student is not required to use materials at the terminal; however, paper and pencil are frequently used as students proceed through the program. Complete data on student performance is collected.

Sample Section of Program

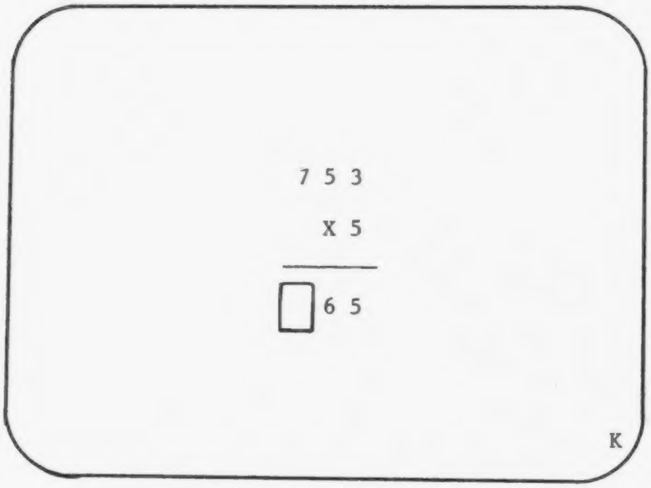
1. Problem is presented



```
 7 5 3
   X 5
 -----
     ☐

                 K
```

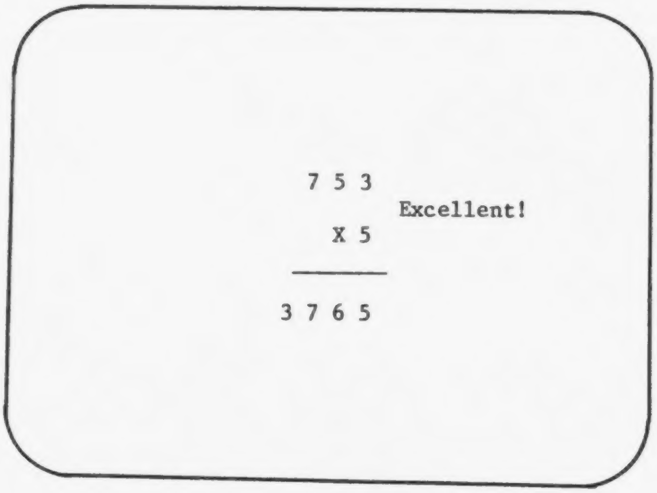
2. Answer in process



```
 7 5 3
   X 5
 -----
 ☐ 6 5

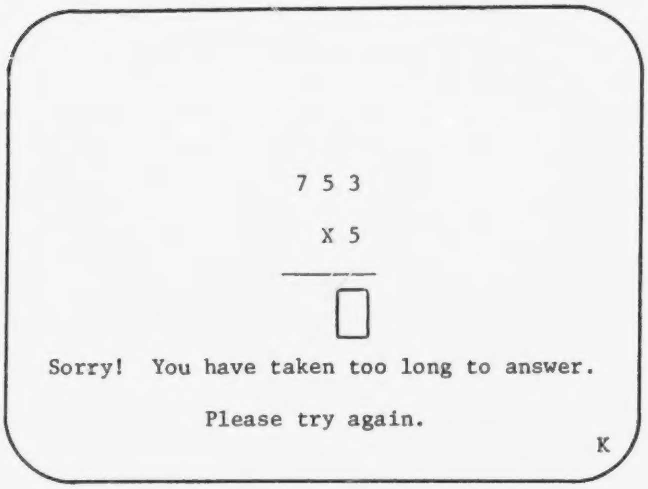
                 K
```

3. Response for a correct answer



```
  7 5 3
          Excellent!
    X 5
  -----
3 7 6 5
```

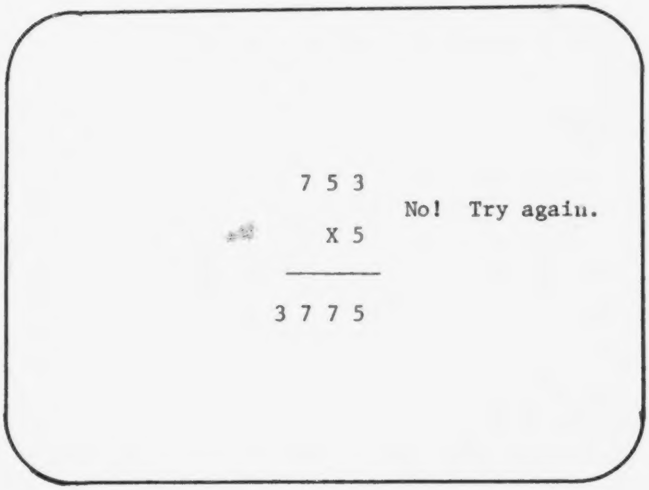
4. Response if student times out the first time



```
       7 5 3
         X 5
       -----
         ☐
Sorry!  You have taken too long to answer.

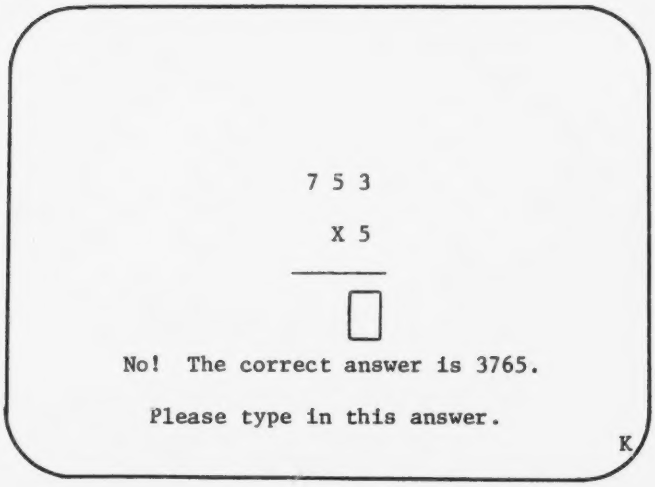
          Please try again.
                                         K
```

5. Response for a first wrong answer



```
   7 5 3    No!  Try again.
     X 5
   -----
 3 7 7 5
```

6. Response for a second wrong answer or a second time-out



```
         7 5 3
           X 5
         -----
           ☐
No!  The correct answer is 3765.

   Please type in this answer.
                                  K
```

Comments

The program was used during the summer of 1969 and the 1969-1970 and 1970-1971 school years. A report on the use of standardized tests to evaluate its effectiveness is given in the validation section. An Operation Whole Numbers manual is given to teachers involved with the program. The manual is used as a guide to interpret proctor messages and to select drill levels for the teacher-assigned drill mode.

b. PROJECT PERIMETER

Need

Initial instruction in finding the perimeter of polygons is provided by this basically tutorial program designed for third and fourth graders. For elementary students, finding the perimeter of polygons is an initial geometric concept. The topic was identified for development because it seemed to be adaptable to computer-assisted instruction and the use of the image projector.

Description

Students enter the program through a diagnostic pretest. After identification by their teachers as third grade independent level readers, criterion test items on the entering and enabling behaviors of the program are presented. An item analysis of student performance on these diagnostic items determines the point at which instruction begins. The student station for this program consists of an IBM 1510 Instructional Display with light pen, and an IBM 1512 Image Projector. The COURSEWRITER II program ends with a posttest. For students who demonstrate mastery on the pretest, a game is provided. The program was written by supporting teachers Ann Cummins and Jean Murdock and teacher specialist Beverly Sangston. Initial coding was performed by Carl Weise. The program is still in process of development.

Terminal Objective

Given three polygons with vertices named and measurements indicated, the student applies the rule for finding the perimeter of a polygon consisting of not more than five line segments with complete accuracy.

Entering Behaviors

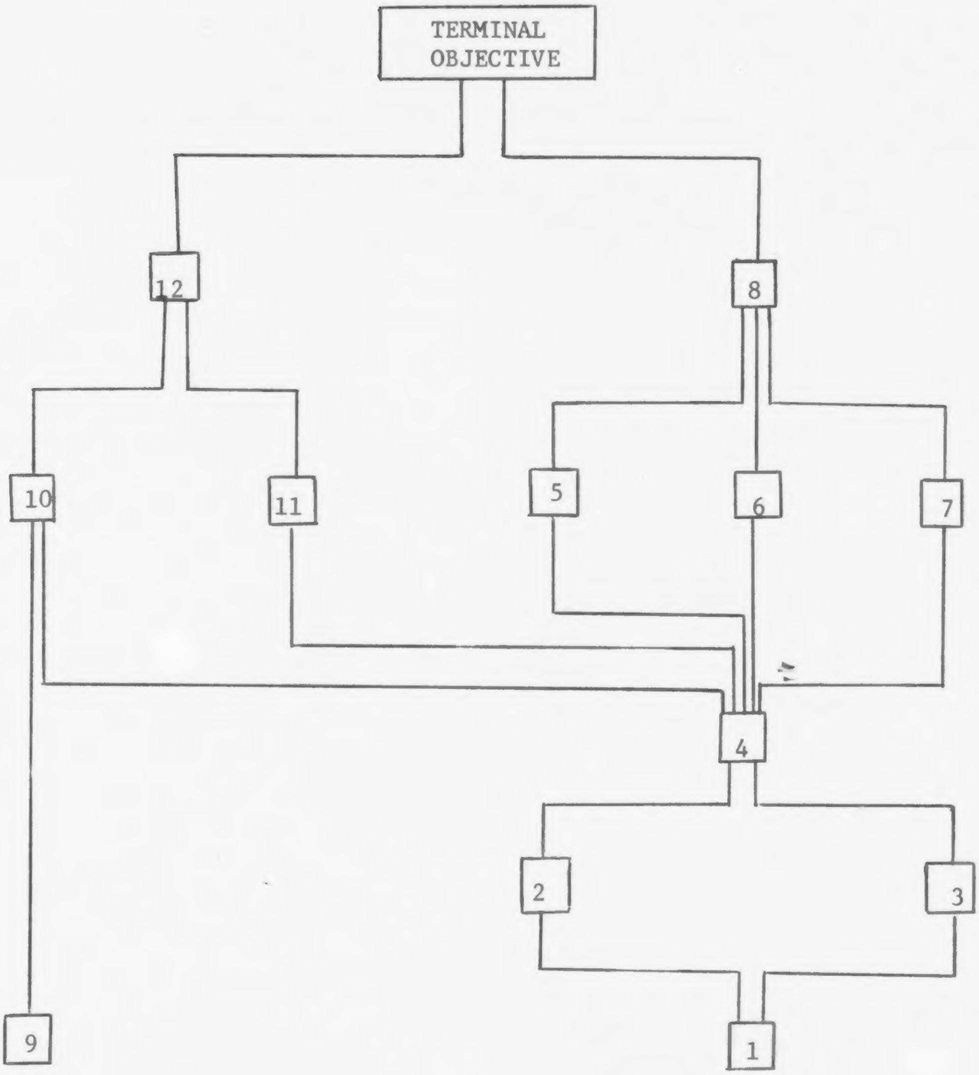
1. Given three illustrations consisting of a line segment, a line, and a ray or point, the student identifies a line segment. Three items of this type are presented; all three answers must be correct.

2. Given three addition problems, the highest level being the addition of 5 two-place numerals with regrouping, the student completes all three problems correctly.

3. Student reads independently on a third grade level, as identified by the classroom teacher.

PROJECT PERIMETER

HIERARCHY


TERMINAL OBJECTIVE
12
8
10
11
5
6
7
4
2
3
9
1

Enabling Objectives

1. Given six open and four closed simple shapes, the student distinguishes between those shapes which are open and those which are closed.

2. Given four open and three closed simple curves, the student identifies the four open simple curves.

3. Given four open and three closed simple curves, the student identifies the three closed simple curves.

4. Given ten simple closed curves (six of these polygons), presented individually, the student distinguishes between those which are polygons and those which are not.

5. Given three triangles and seven other polygons, the student identifies the triangles.

6. Given four quadrilaterals and three other polygons the student distinguishes between those which are quadrilaterals and those which are not.

7. Given two pentagons and four other polygons, the student identifies the pentagons.

8. Given ten polygons, made up of three, four, or five line segments, the student names each one as a triangle, quadrilateral, or pentagon with 100 per cent accuracy.

9. Given four line segments with labeled end points, the student names each segment.

10. Given two polygons with vertices named and measures of line segments given, the student writes all of the number sentences of equality. (Example: AB=6)

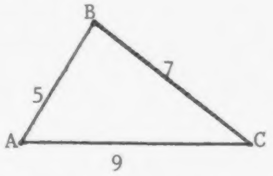
11. The student identifies the perimeter of a polygon as the distance around the polygon.

12. The student identifies the rule for finding the perimeter of a polygon. (Perimeter equals the sum of the measures of the line segments.)

Pretest and Posttest

For the three polygons presented individually with vertices named and measurements indicated, the student calculates the perimeter. Criteria for success is three correct.

Find the perimeter of this polygon.

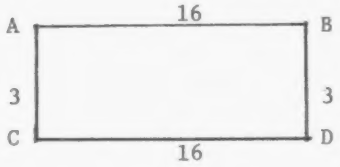


Use the keys to type in your answer.

The perimeter is ___.

K

Find the perimeter of this polygon.

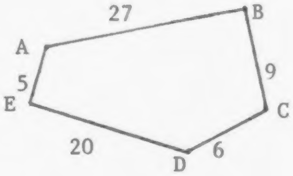

A
16
B
3
3
C
D
16

Use the keys to type in your answer.

The perimeter is ___.

K

Find the perimeter of this polygon.


27
B
A
9
5
E
C
20
6
D

Use the keys to type in your answer.

The perimeter is ___.

K

Mode of Presentation

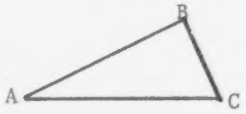
Instruction is totally CAI for this modular instructional package with the cathode ray tube, keyboard, and light pen providing a variety of presentation and response modes.

Sample Section of Program

A polygon with 3 sides is called a

TRIANGLE.

This is a triangle.

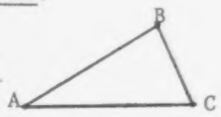


S

A polygon with 3 sides is called a

TRIANGLE.

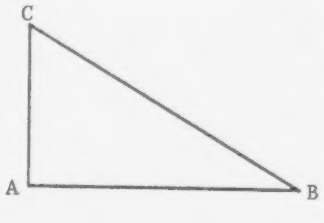
This is a triangle.



TRI means 3.

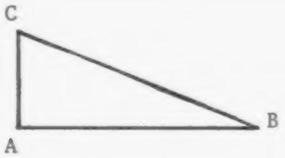
A triangle is a polygon made of three line segments.

S



This polygon is made of 3 line segments.

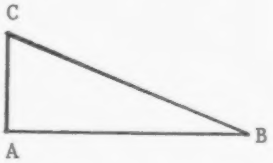
S



This polygon is made of 3 line segments.

The special name given to a 3-sided
polygon is a
☐ Square
☐ Triangle
☐ Circle

P

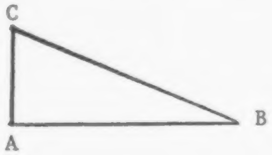


This polygon is made of 3 line segments.

The special name given to a 3-sided
polygon is a

Triangle Excellent!

S

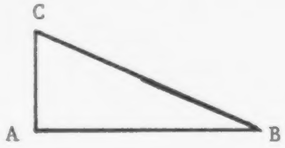


This polygon is made of 3 line segments.

The special name given to a 3-sided

polygon is a ☐_______________.

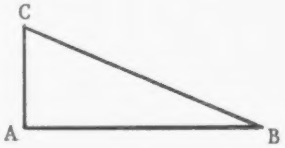
K



This polygon is made of ? line segments.

The special name given to a 3-sided polygon is a triangle.

S



This polygon is made of 3 line segments.

The special name given to a 3-sided polygon is a triangle.

Good!

S

Look at the image projector.

What color are the triangles?

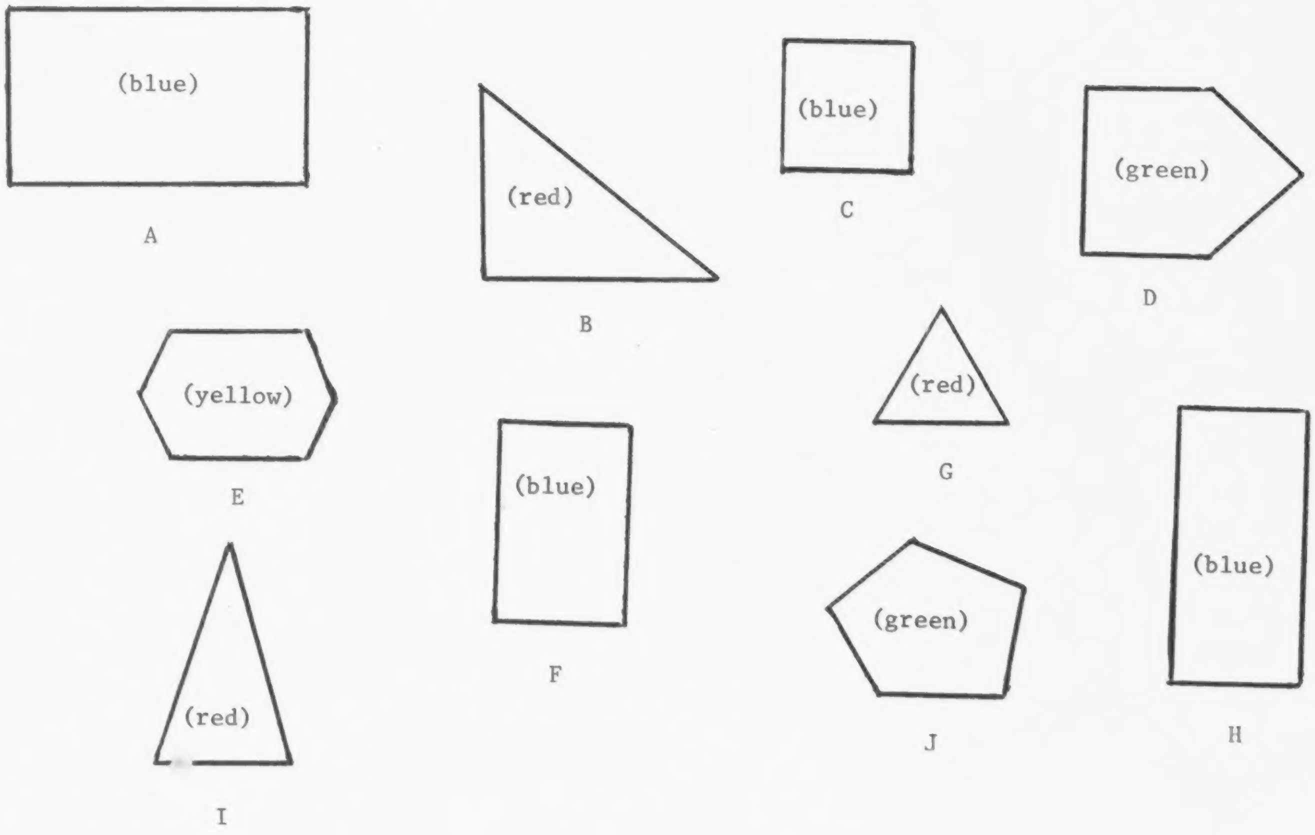
☐ Green

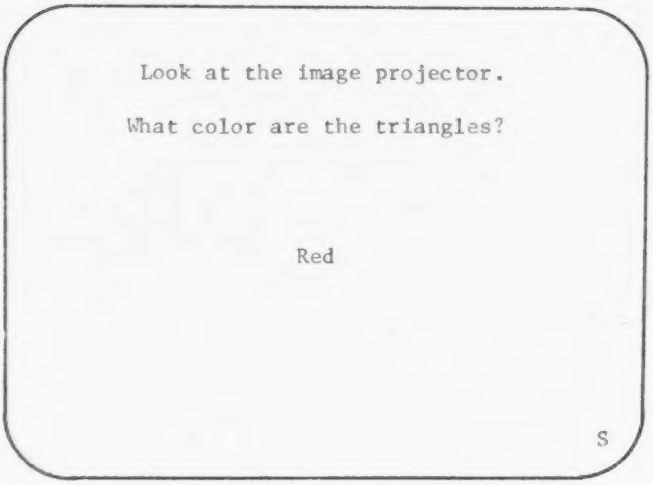
☐ Red

☐ Blue

P

SAMPLE IMAGE PROJECTOR FRAME


(blue)
A
(red)
B
(blue)
C
(green)
D
(yellow)
E
(blue)
F
(red)
G
(blue)
H
(red)
I
(green)
J

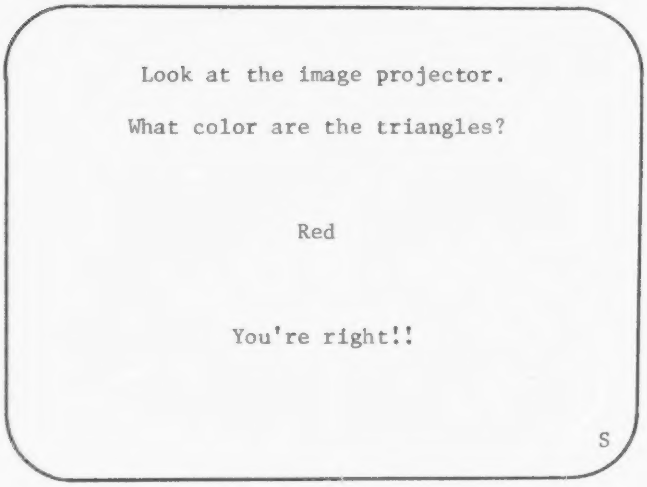


Look at the image projector.

What color are the triangles?

Red

S



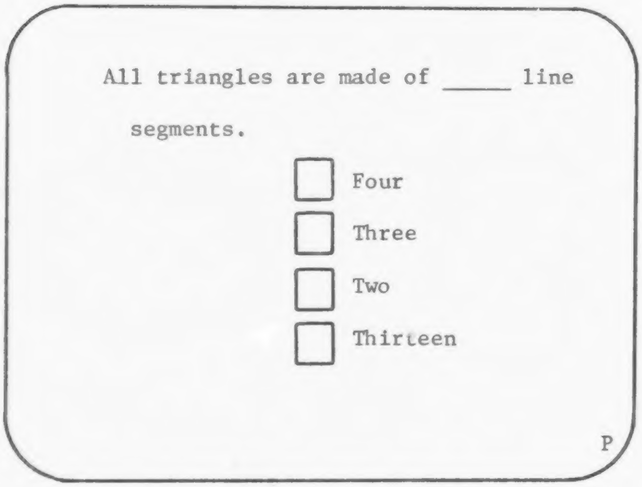
Look at the image projector.

What color are the triangles?

Red

You're right!!

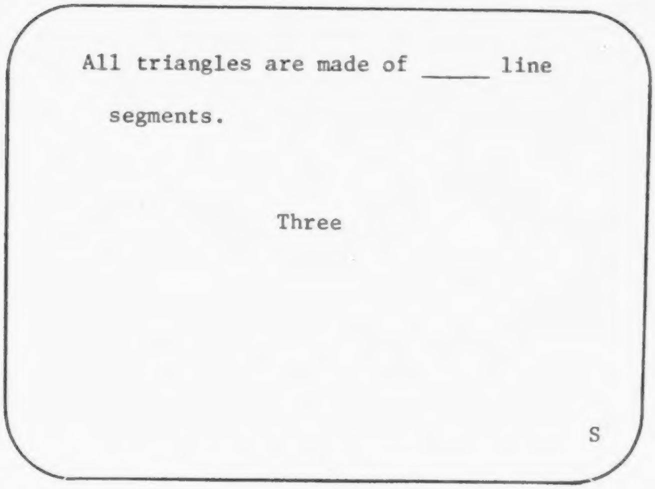
S



All triangles are made of _____ line segments.

☐ Four
☐ Three
☐ Two
☐ Thirteen

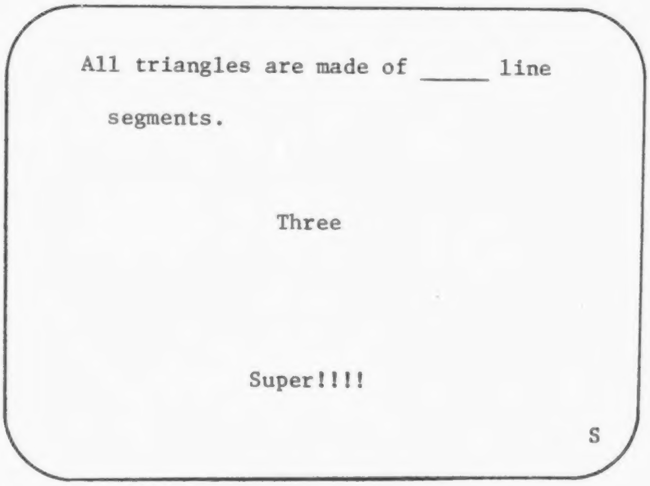
P



All triangles are made of _____ line segments.

Three

S



All triangles are made of _____ line segments.

Three

Super!!!!

S

Comments

One design team member continues to author this segment, but the design team leader has needed to expend her efforts on other programs during Phase III; hence, the modular instructional package is still under development.

c. LEARNING ABOUT PER CENTS

Need

The concepts necessary for acquiring skills in the use of per cents are difficult for many 5th and 6th grade students. The area was selected for development as a tutorial dialogue to provide the needed subject area work through employing the computer's capabilities for branching according to responses.

Description

Common fraction/per cent and decimal/per cent are the two parts of the program. LEARNING ABOUT PER CENTS was designed for mathematically gifted students in the upper elementary grades. It will be used with students in grades 5 through 8 for initial instruction and review. This tutorial dialogue was written by Donna Kirsch, a supporting teacher, and Beverly Sangston, design team leader. The instructional display with light pen and image projector are the student terminal requirements.

Terminal Objectives

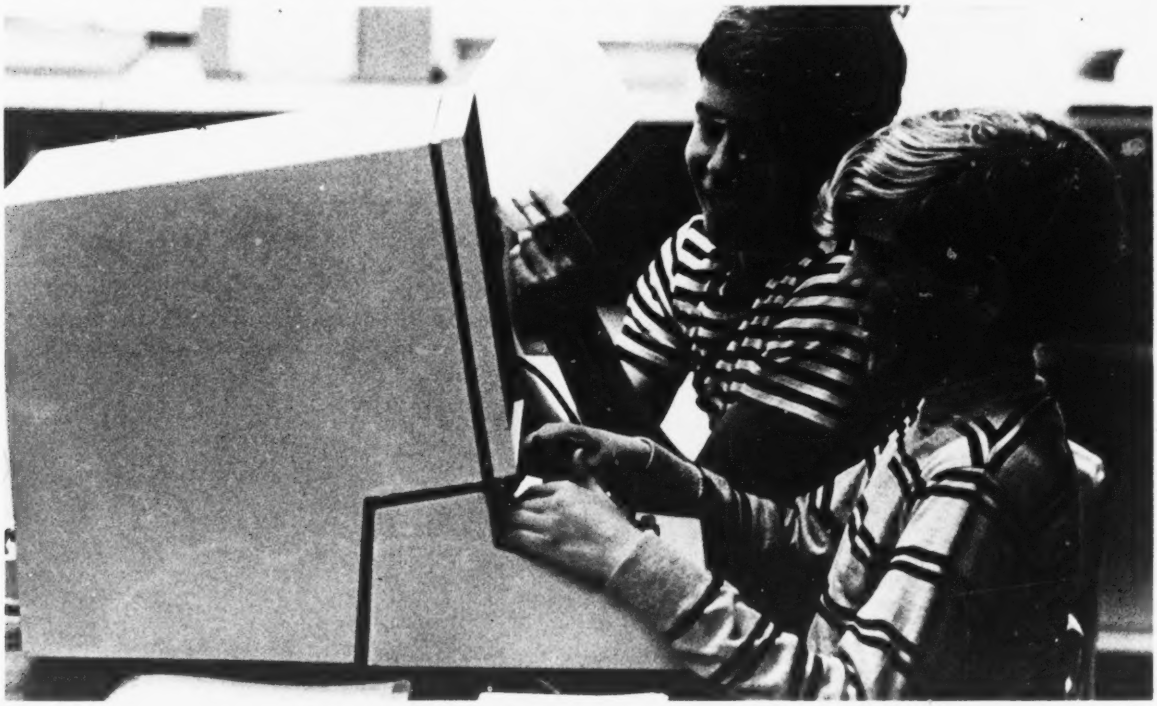
For success in this program, 90 per cent of the criterion items for each objective must be attained.

(A) Given 10 common fractions having denominators that are either 2, 4, 5, 10, 20, 25, or 50 the student writes the per cent for each.

(B) Given 10 per cents the student writes a common fraction in lowest terms for each per cent.

(C) Given 10 decimals less than or equal to one, written in tenths or hundredths, the student writes the per cent for each.

(D) Given 10 integral per cents, the student writes the decimal for each per cent.



Entering Behaviors

I – Common Fractions

1. Given a common fraction, the student identifies the numerals which represent the numerator and the denominator.

2. Given the terms *numerator* and *denominator* and their definitions, the student identifies the definition for each term.

3. Given an illustration of a collection of objects in which one or more are designated in some way, the student gives a fractional name for this illustration. Two problems are presented for this behavior; both must be answered correctly.

4. Given fractional number sentences in the form $a = c$ with one missing term in each sentence, the student names the missing term. The denominators are 2, 4, 5, 10, 20, 25, 50 or 100. Criterion for success is six of the seven sentences.

5. Given six fractions with denominators of 4, 10, 20, 25, 50, and 100, the student names at least five fractions in lowest terms.

II – Decimals

1. Given three decimals with digits in tenths and hundredths and a list of place values, the student identifies the place value of the digits.

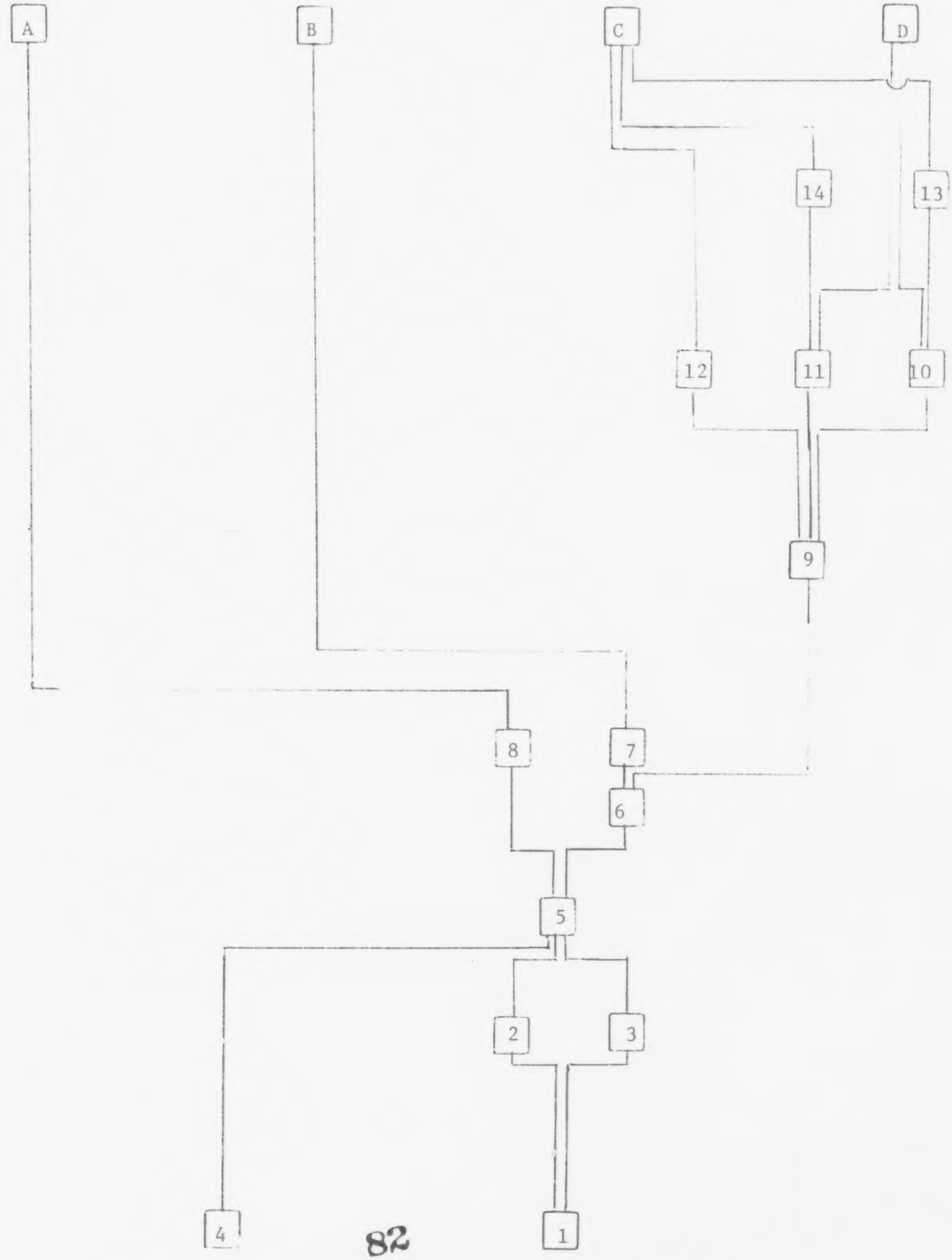
2. Given a decimal numeral with digits in the tens, ones, tenths, and hundredths places, the student names the numeral in the tenths place, as tenths and the numeral in the hundredths place, as hundredths.

3. Given seven decimals with digits in tenths and hundredths places and a fraction with a denominator of 100, the student names the numerator for each.

4. Given eight common fractions with denominators of 10 or 100, the student names the decimal equivalent for at least seven.

5. Given seven common fractions with denominators of 2, 4, 5, 20, 25, and 50, the student names a decimal equivalent for at least six.

HIERARCHY FOR LEARNING ABOUT PER CENTS


A
B
C
D
14
13
12
11
10
9
8
7
6
5
2
3
4
1

Enabling Objectives

1. Given four symbols including %, the student identifies the sign for per cent.

2. Given two numbers with the per cent symbol, the student writes the numerals with the word per cent.

3. Given three number sentences in the form n per cent = n___, the student constructs the symbol for per cent.

4. Given two sentences describing a fraction with a denominator of 100 and given one of the terms for the fraction, the student names the missing term for each sentence.

5. Given eight fractions with denominators of 100, the student names the per cents for at least seven fractions.

6. Given eight sentences with any integral per cent greater than or equal to 1 per cent and less than or equal to 100 per cent and given denominators of 100, the student names the missing numerators for at least seven of these per cents.

7. Given nine sentences with any integral per cent equal to or greater than 1 per cent and less than 99 per cent, the student names a fractional equivalent in lowest terms for at least eight.

8. Given nine fractions with denominators which are factors of 100, the student names the per cent for at least eight.

9. Given 100 per cent, the student writes the decimal (1.00 or 1).

10. Given eight integral per cents greater than or equal to 10 per cent and less than or equal to 99 per cent the student writes the decimal for at least seven.

11. Given three integral per cents greater than or equal to 1 per cent and less than or equal to nine per cent, the student writes the decimal for each.

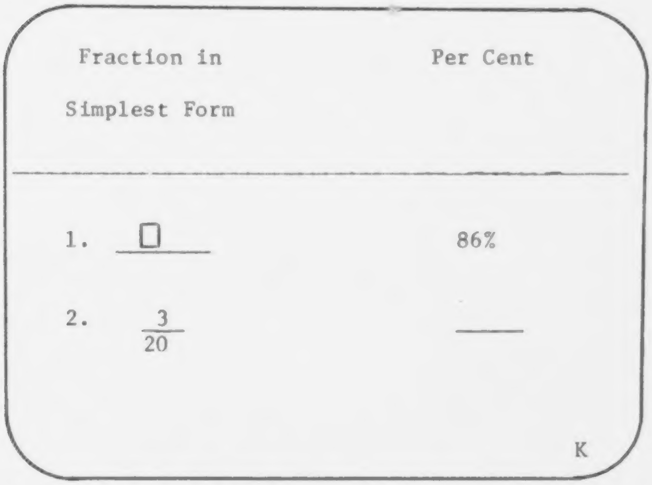
12. Given the decimal 1.00, the student writes the per cent (100%).

13. Given eight decimals in hundredths greater than or equal to .10 and less than or equal to .99, the student writes the per cent for at least seven.

14. Give three decimals in hundredths greater than or equal to .01 and less than or equal to .09, the student writes the per cent for each.

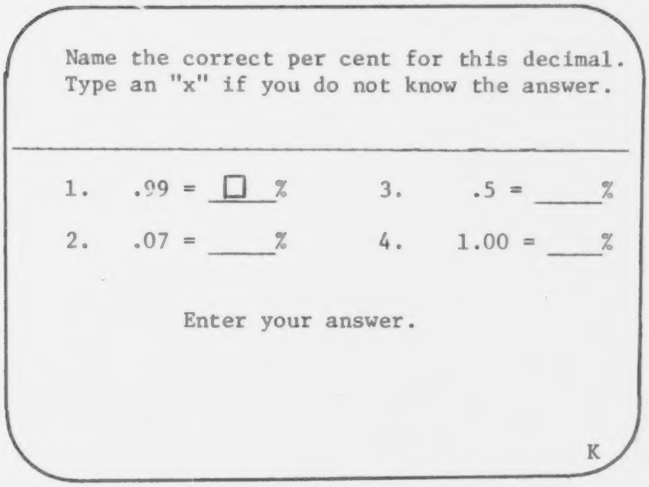
Pretest and Posttest

The student's first encounter with the program is the presentation of criterion items on the common fraction/per cent terminal objectives. If the student demonstrates mastery of these behaviors (90 per cent) he will be presented criterion items on the decimal/per cent terminal objectives. The student's performance on these items indicates whether or not a need exists for instruction.



Fraction in Simplest Form	Per Cent
1. ☐	86%
2. $\frac{3}{20}$	____

K

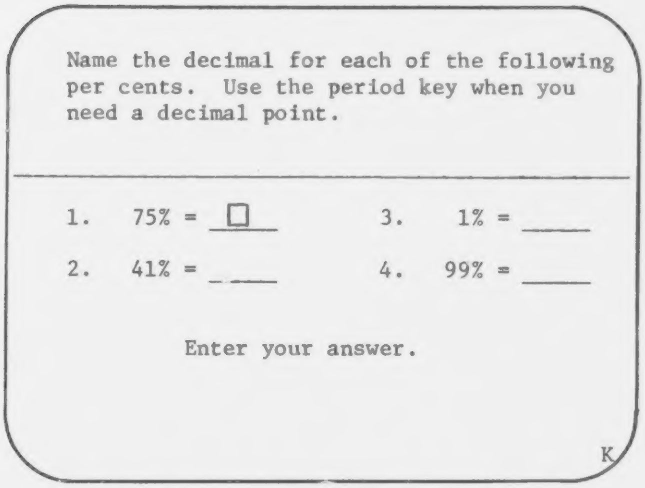


Name the correct per cent for this decimal.
Type an "x" if you do not know the answer.

1. .99 = ☐ %   3. .5 = ____%
2. .07 = ____%   4. 1.00 = ____%

Enter your answer.

K



Name the decimal for each of the following per cents. Use the period key when you need a decimal point.

1. 75% = ☐   3. 1% = ____
2. 41% = ____   4. 99% = ____

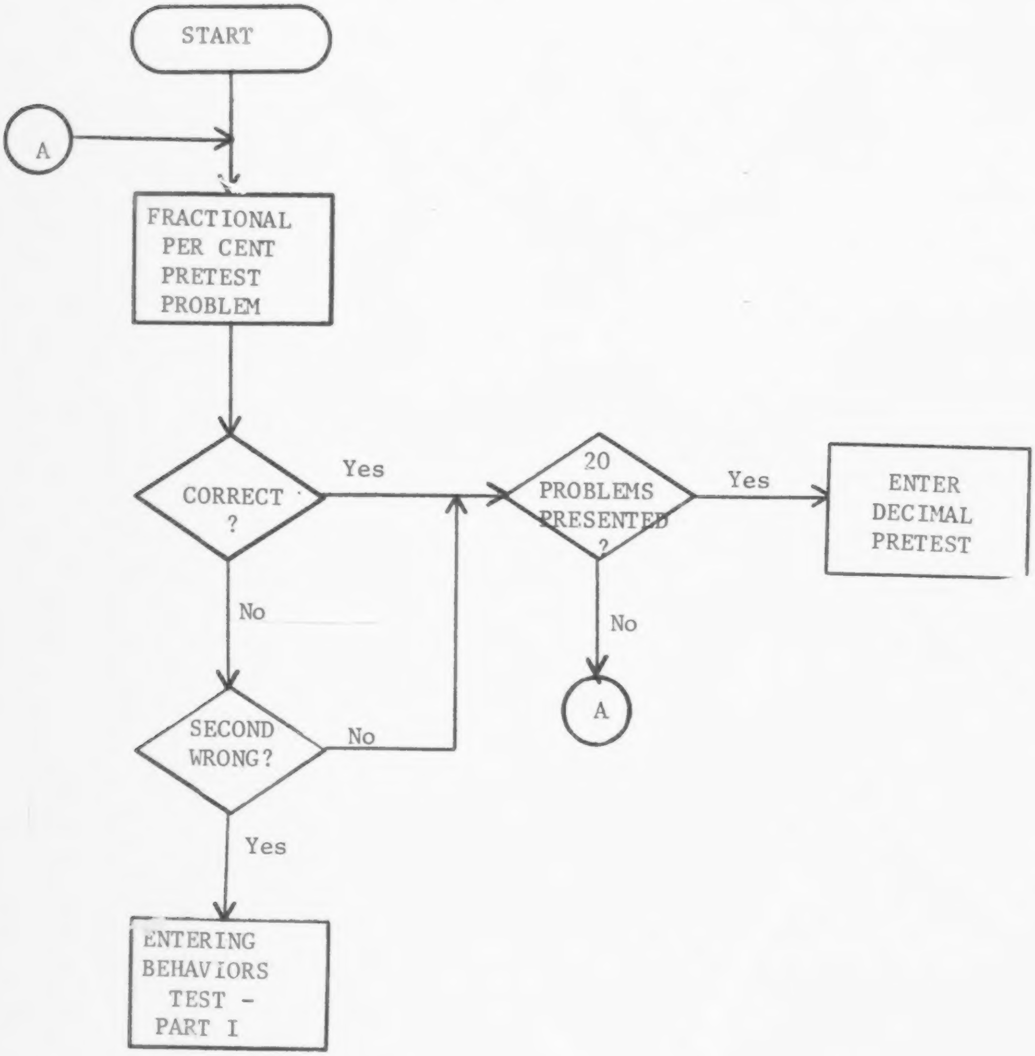
Enter your answer.

K

LEARNING ABOUT PER CENTS

PART I

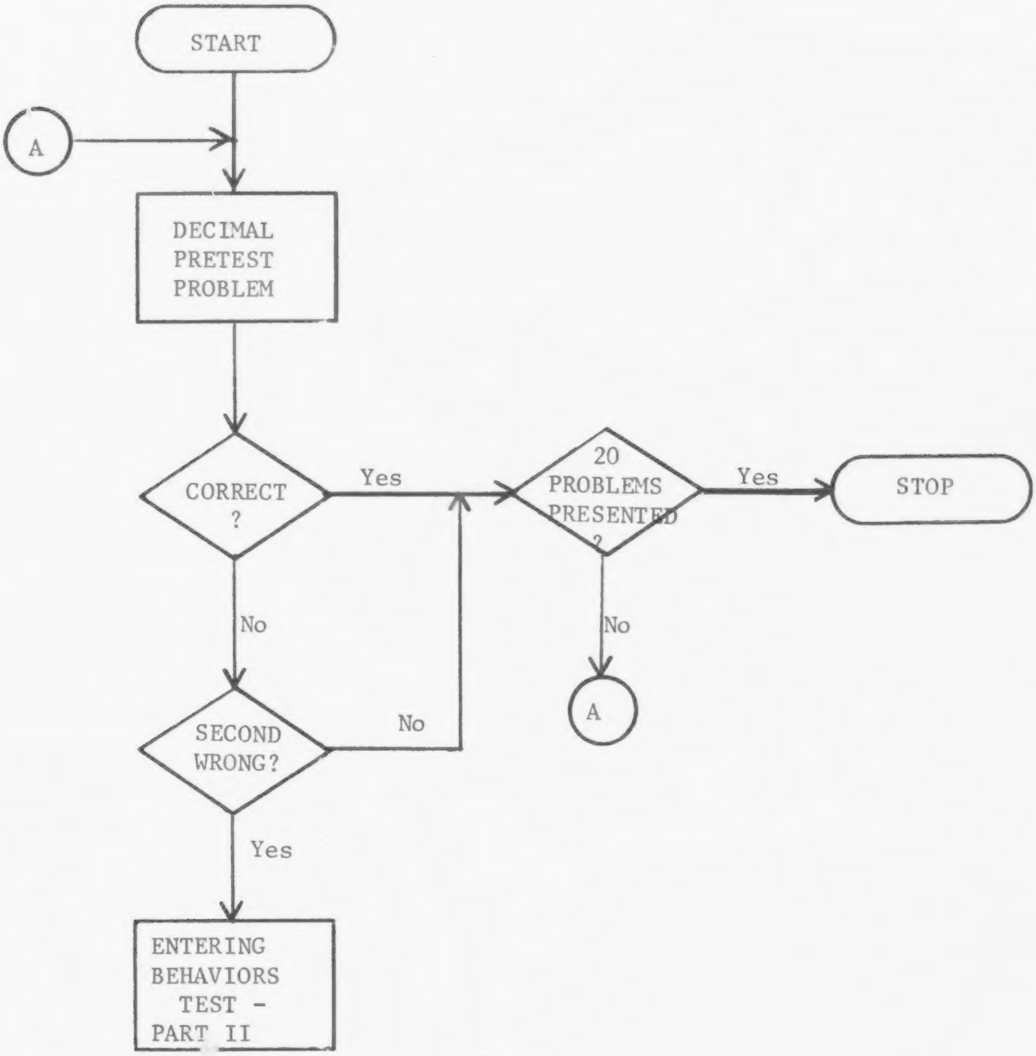
PRETEST STRATEGY


START
A
FRACTIONAL PER CENT PRETEST PROBLEM
CORRECT ?
Yes
No
SECOND WRONG?
No
Yes
ENTERING BEHAVIORS TEST - PART I
20 PROBLEMS PRESENTED ?
Yes
No
ENTER DECIMAL PRETEST
A

LEARNING ABOUT PER CENTS

PART II

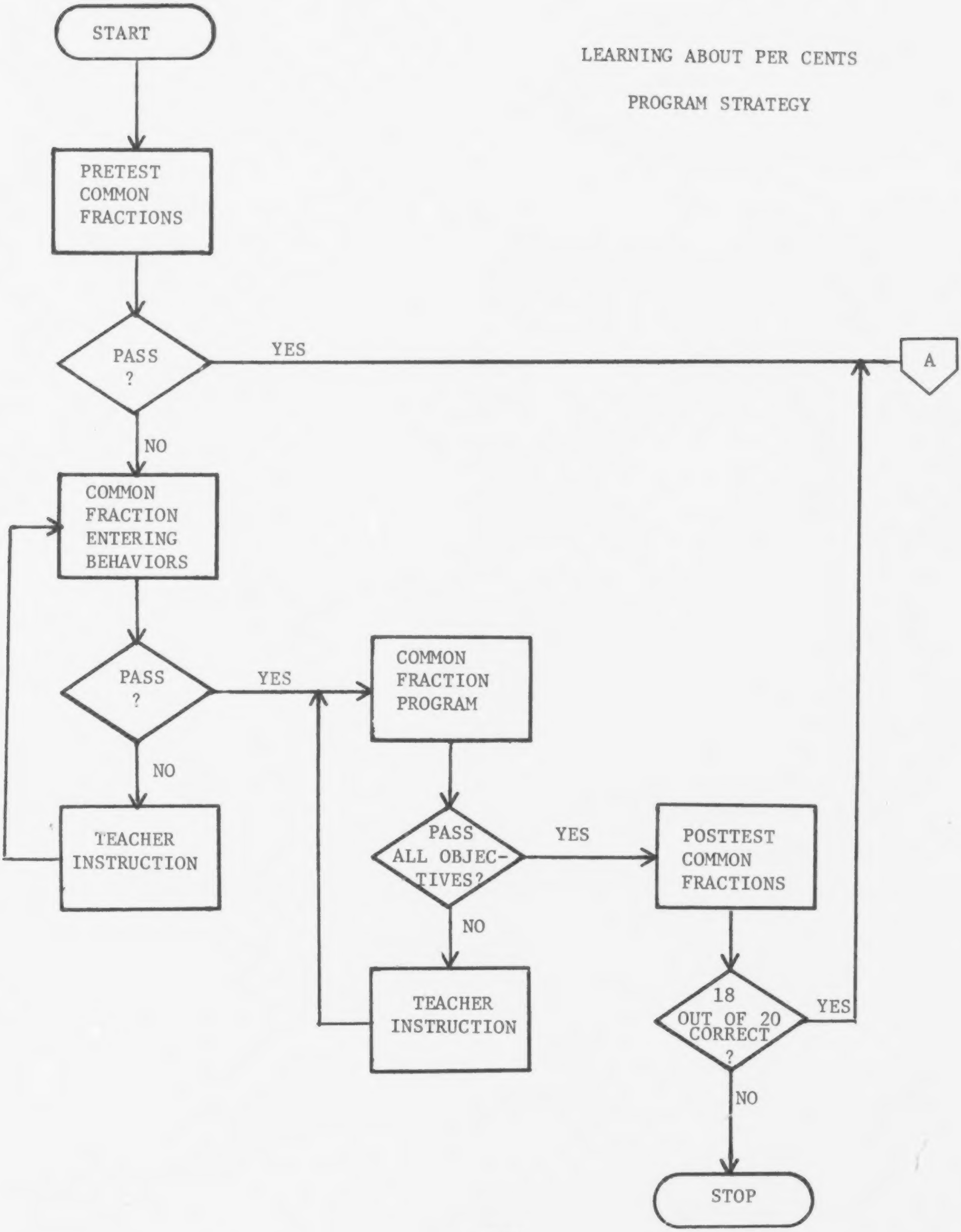
PRETEST STRATEGY


START
A
DECIMAL PRETEST PROBLEM
CORRECT ?
Yes
No
SECOND WRONG?
No
Yes
ENTERING BEHAVIORS TEST - PART II
20 PROBLEMS PRESENTED ?
Yes
STOP
No
A

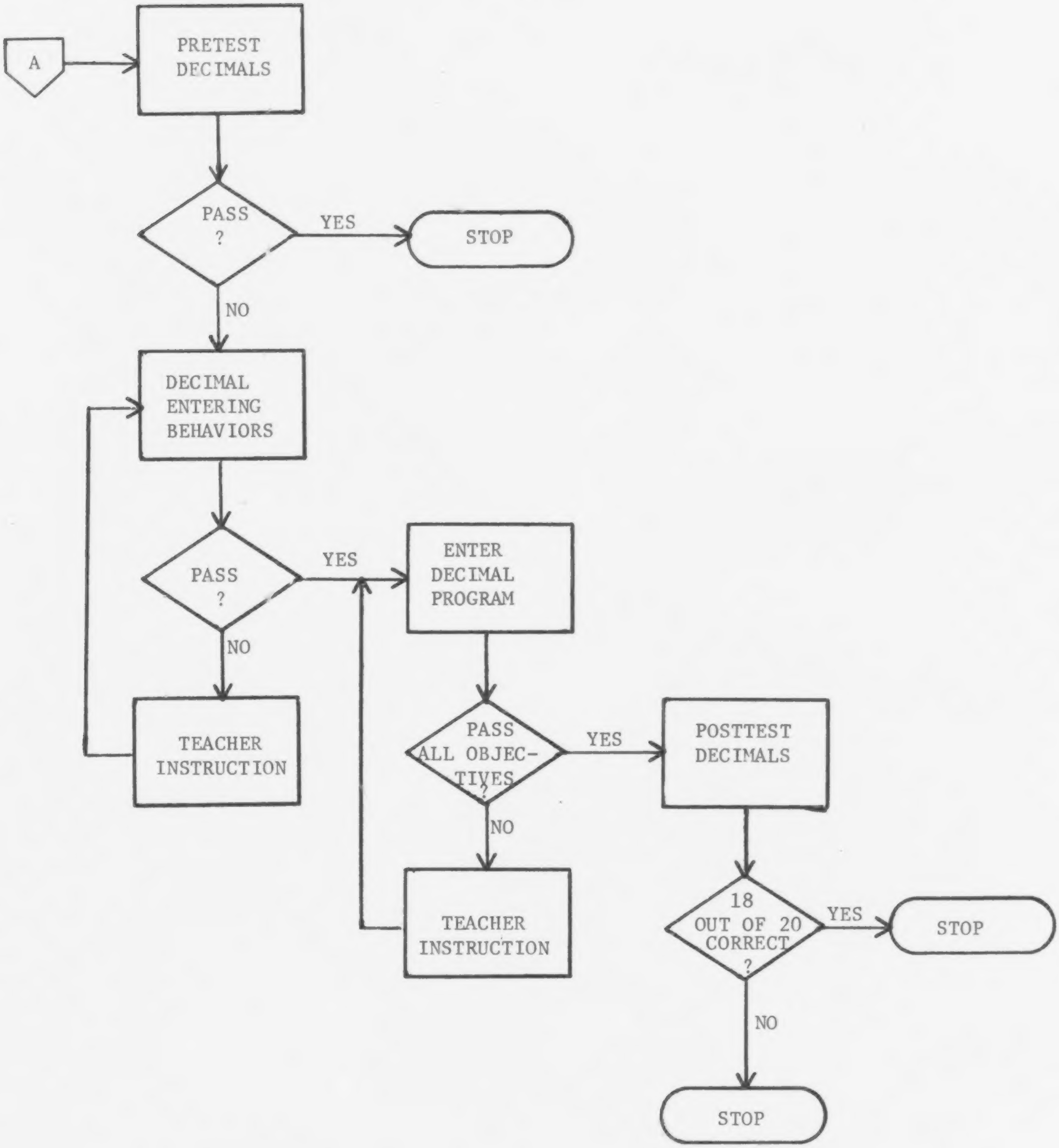
86

LEARNING ABOUT PER CENTS

PROGRAM STRATEGY

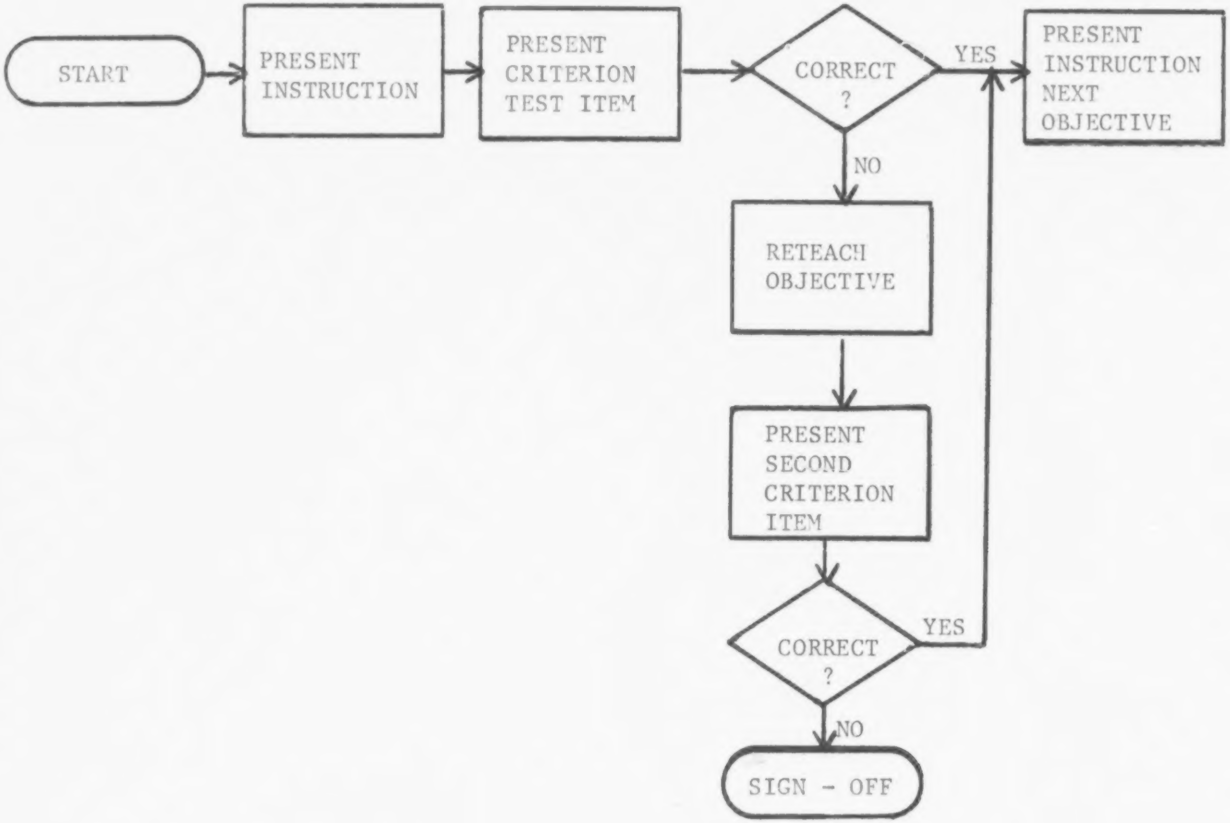


START
PRETEST COMMON FRACTIONS
PASS ?
YES
A
NO
COMMON FRACTION ENTERING BEHAVIORS
PASS ?
YES
NO
TEACHER INSTRUCTION
COMMON FRACTION PROGRAM
PASS ALL OBJECTIVES?
YES
NO
TEACHER INSTRUCTION
POSTTEST COMMON FRACTIONS
18 OUT OF 20 CORRECT ?
YES
NO
STOP


A
PRETEST DECIMALS
PASS ?
YES
STOP
NO
DECIMAL ENTERING BEHAVIORS
PASS ?
YES
NO
ENTER DECIMAL PROGRAM
TEACHER INSTRUCTION
PASS ALL OBJECTIVES ?
YES
NO
POSTTEST DECIMALS
TEACHER INSTRUCTION
18 OUT OF 20 CORRECT ?
YES
STOP
NO
STOP

83

LEARNING ABOUT PER CENTS - INSTRUCTIONAL STRATEGY


START
PRESENT INSTRUCTION
PRESENT CRITERION TEST ITEM
CORRECT ?
YES
PRESENT INSTRUCTION NEXT OBJECTIVE
NO
RETEACH OBJECTIVE
PRESENT SECOND CRITERION ITEM
CORRECT ?
YES
NO
SIGN - OFF

Mode of Presentation

The tutorial package is designed for the terminal consisting of instructional display with keyboard and light pen, and image projector. No additional materials are required at the student station.

Sample Section of Program

Let's go back to the problem about the 25 red apples and the 75 green apples. Using our two fractions with denominators of 100, we will name two per cents for the red and green apples.

S

25 out of the 100 apples are red.

$\frac{25}{100}$ of all the apples are red.

$\frac{25}{100}$ names 25%

25% of all the apples are red.

S

All per cents name a certain number of hundredths.

Twenty-five hundredths names twenty-five per cent.

$$\frac{25}{100} = 25\%$$

S

Since 75 of all the 100 apples are green, then . . .

$\frac{75}{100}$ of all the apples are green.

$\frac{75}{100}$ names what per cent? ____

S

Since 75 of all the 100 apples are green, then . . .

$\frac{75}{100}$ of all the apples are green.

$\frac{75}{100}$ names what per cent? 75%

Good!

S

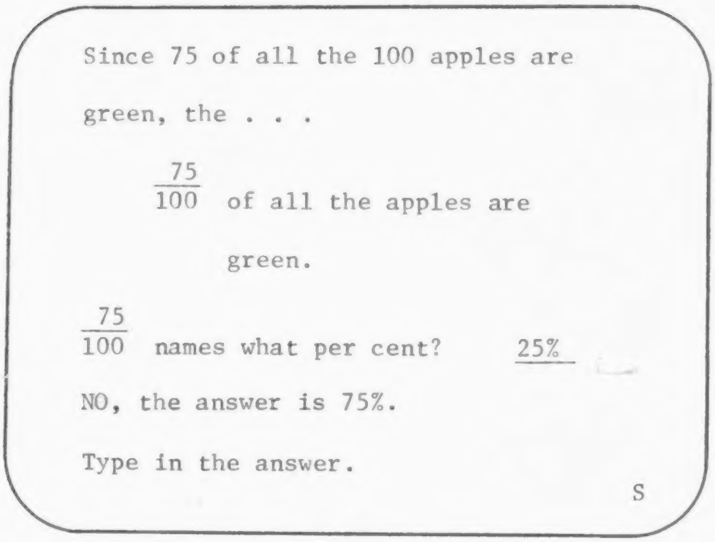
Since 75 of all the 100 apples are green, then . . .

$\frac{75}{100}$ of all the apples are green.

$\frac{75}{100}$ names what per cent? 25%

Try again!

S



Since 75 of all the 100 apples are green, the . . .

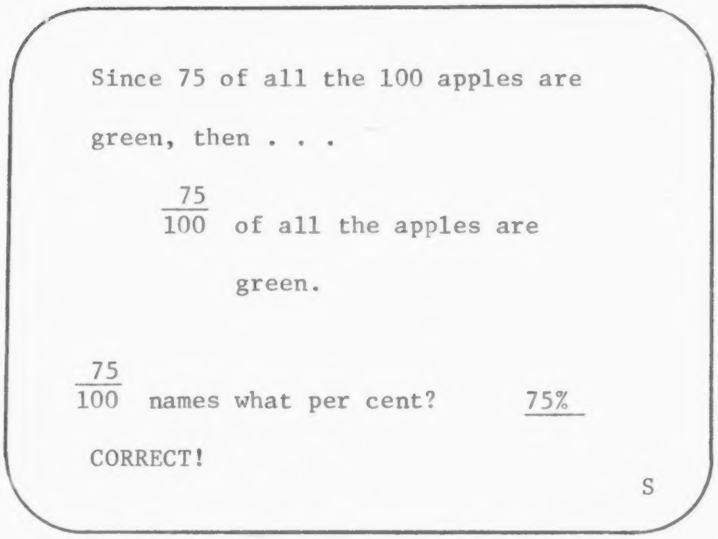
$\frac{75}{100}$ of all the apples are green.

$\frac{75}{100}$ names what per cent? 25%

NO, the answer is 75%.

Type in the answer.

S



Since 75 of all the 100 apples are green, then . . .

$\frac{75}{100}$ of all the apples are green.

$\frac{75}{100}$ names what per cent? 75%

CORRECT!

S

Comments

Per cents is one of the topics of the 7th and 8th grade MCPS mathematics curriculum. While upper elementary grade mathematics textbooks usually include the subject per cents, project staff members with mathematics teaching experience believe the subject matter requires mastery of entering behaviors not possessed by most elementary school children.

Learning About Per Cents will be used with a junior high school target population and those elementary students with the necessary entering behaviors during the 1971-72 school year. This program has been pilot tested with a few students but has not been validated.

d. WORD SEARCH (DICTIONARY SKILLS)

Need

Use of the dictionary is an important skill taught in third and fourth grades. When language arts was selected as an area for modular instructional package development, dictionary skills seemed to be a topic adaptable to computer-assisted instruction.

Much classroom time is spent in instruction in the use of the dictionary; the authors felt that because a modular instructional package identifies problem areas and individualizes instruction, the objectives could be attained in a shorter period of time through CAI.

Description

Word Search provides an introduction to the dictionary. Instruction in the skills necessary for its use and practice in applying these skills with a beginning dictionary are included in a tutorial dialogue, total instruction learning package which features use of a dictionary at the terminal. The program can be used as an initial instructional package or as remedial instructional material. Developed by Mary Adele White, S.N.D. de N., the parochial schools representative, and Beverly Sangston, teacher specialist, the segment is being coded in COURSEWRITER II. The program is designed for use at a terminal with these components: IBM 1510 Instructional Display with light pen, and IBM 1512 Image Projector. A Thorndike Barnhart Beginning Dictionary is the keyed reference. The segment is still in development.

Terminal Objective

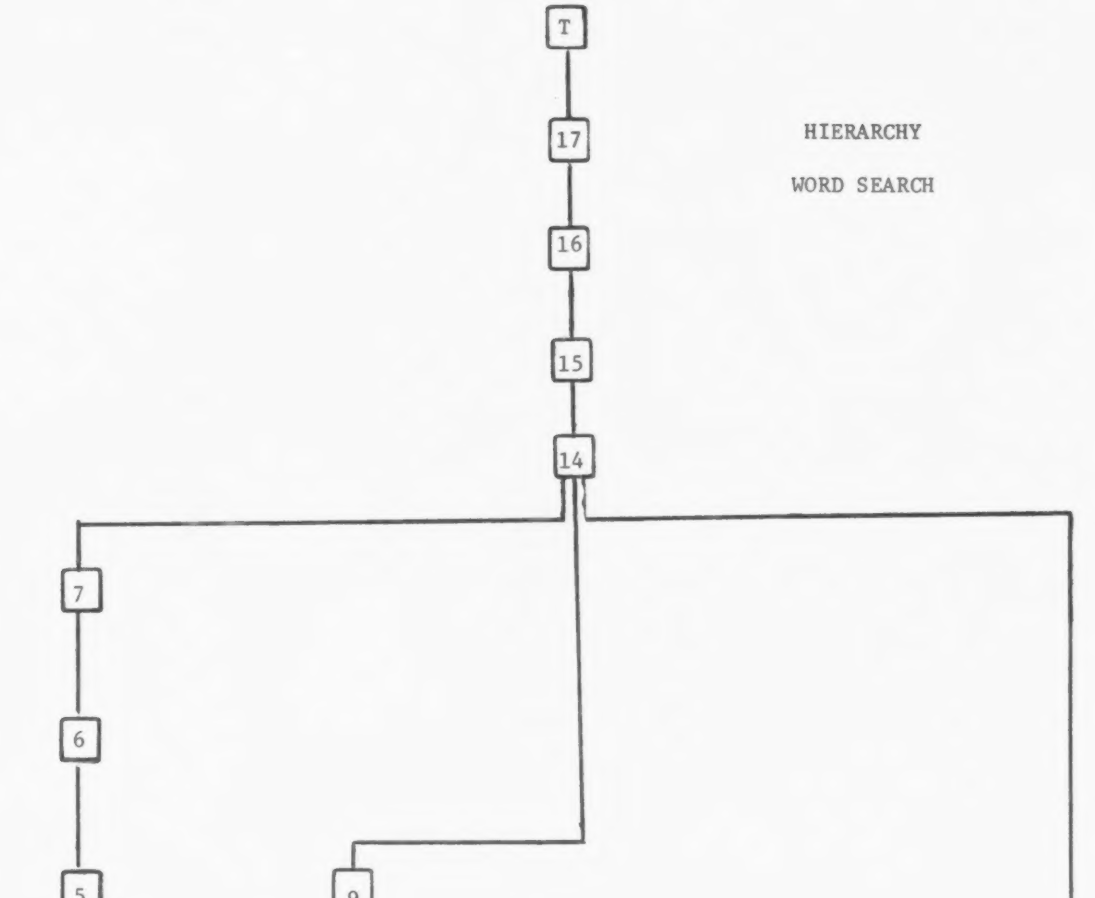
Given a list of ten words, the student chooses four which he locates in the dictionary by the use of "guide words". For each of the four words selected, three phrases, including a definition are presented; the student identifies the definition for each word. Mastery is 100 per cent attainment.

Entering Behaviors

Students must have a third grade reading vocabulary and write the letters of the alphabet in order before beginning the program. The classroom teacher identifies the students with these skills.

HIERARCHY

WORD SEARCH


T
17
16
15
14
7
6
5
9
4
3
13
12
1
2
8
10
11

Enabling Objectives

1. Given five letters of the alphabet, the student identifies the one that comes last in alphabetical order.

2. Given five letters of the alphabet, the student identifies the one that comes first in alphabetical order.

3. Given five letters of the alphabet, the student writes them in alphabetical order.

4. Given five letters and the groupings (A to G), (H to P), and (Q to Z), the student identifies the beginning (A to G), middle (H to P), or end (Q to Z) of the alphabet as the location of each letter.

5. Given five one syllable words beginning with different letters, the student orders them alphabetically.

6. Given two words beginning with the same letter, the student orders them alphabetically.

7. Given three words beginning with the same two letters, the student orders them alphabetically.

8. Given a dictionary, the student identifies the arrangement of the words listed in a dictionary as alphabetical order.

9. Given three one syllable words beginning with different letters and the groupings (A to G), (H to P), and (Q to Z), the student identifies a beginning, middle, or end of the dictionary location for each word.

10. Given a copy of a dictionary page and nine words including the entry words for that page, the student identifies the entry words.

11. Given a copy of a dictionary page and three sets of guide words including the guide words for that page, the student identifies the guide words for that page.

12. Given a copy of a dictionary page with the guide words covered, and three sets of guide words including the ones for that page, the student identifies the guide words for that page.

13. Given an entry word and three sets of guide words including the set for the entry word, the student identifies the guide words the given word would fall between.

14. Given five words beginning with different letters, the student locates the page on which they are found in the dictionary.

15. Given three words beginning with the same or different letters, the student locates the page on which each word is found in the dictionary.

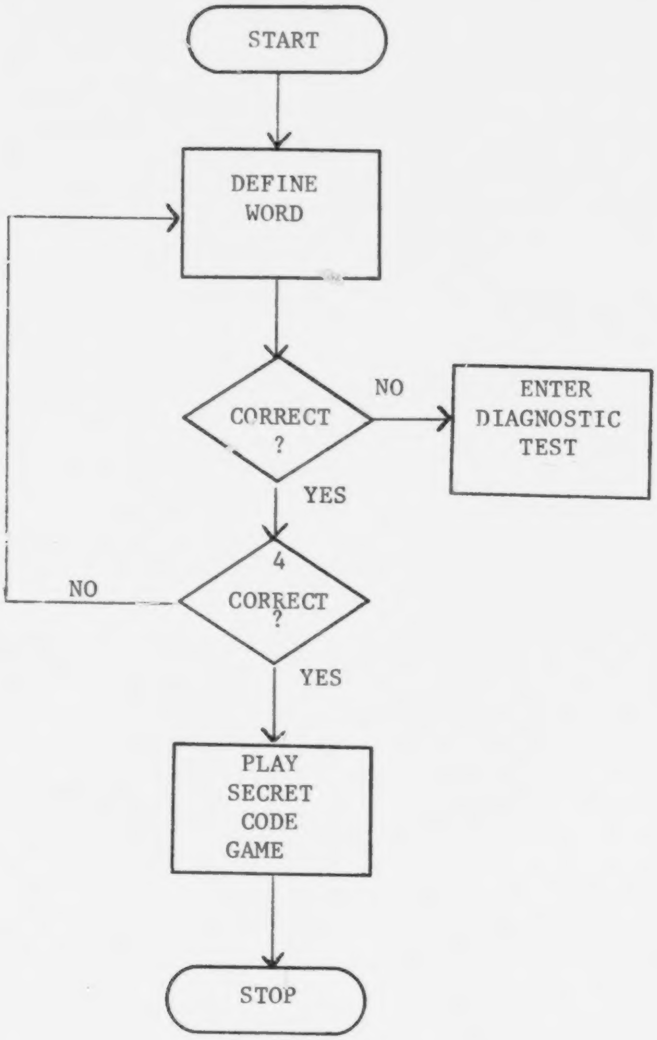
16. Given a definition and three entry words, the student identifies the entry word defined by the given definition.

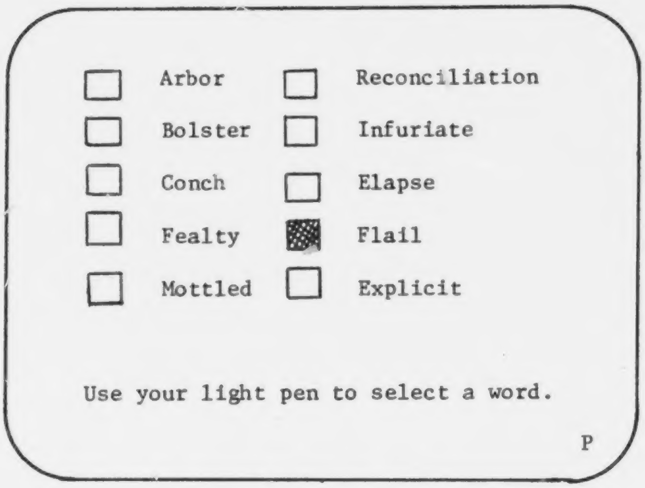
17. Given two words beginning with different letters with three definitions for each, only one being correct, the student identifies the correct definition for each by using his dictionary.

Pretest and Posttest

The words selected for the criterion items on the terminal objective are words not in the reading vocabulary for third and fourth grades.

WORD SEARCH - PRETEST STRATEGY

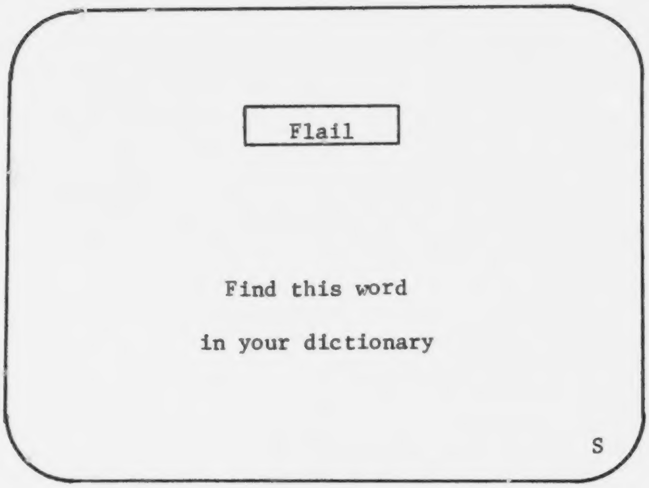

START
DEFINE WORD
CORRECT ?
NO
ENTER DIAGNOSTIC TEST
YES
4 CORRECT ?
NO
YES
PLAY SECRET CODE GAME
STOP



☐ Arbor ☐ Reconciliation
☐ Bolster ☐ Infuriate
☐ Conch ☐ Elapse
☐ Fealty ▨ Flail
☐ Mottled ☐ Explicit

Use your light pen to select a word.

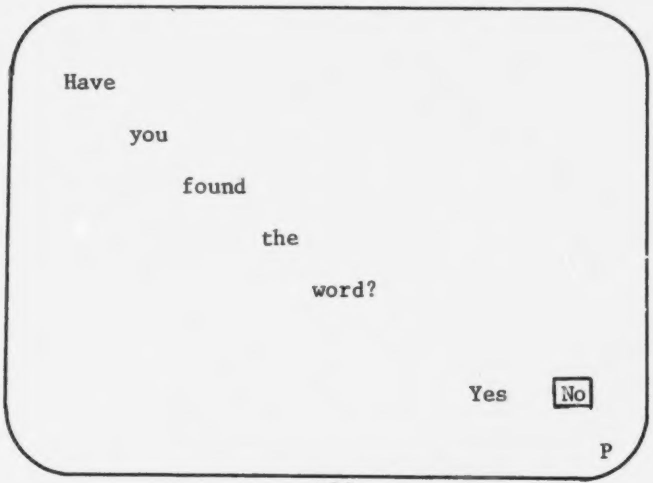
P



Flail

Find this word
in your dictionary

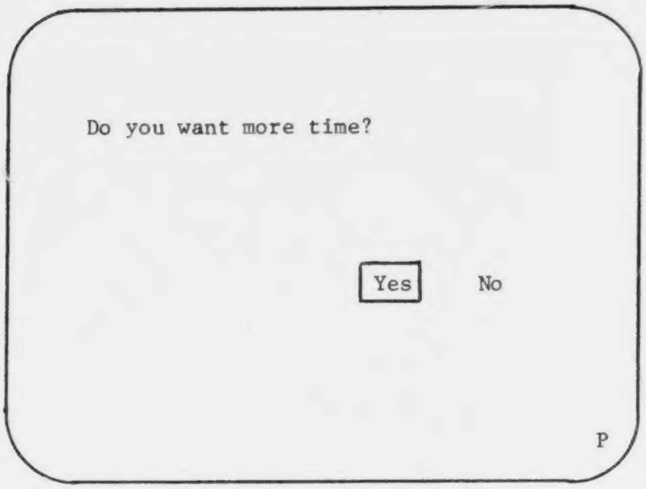
S



Have
you
found
the
word?

Yes [✓ No]

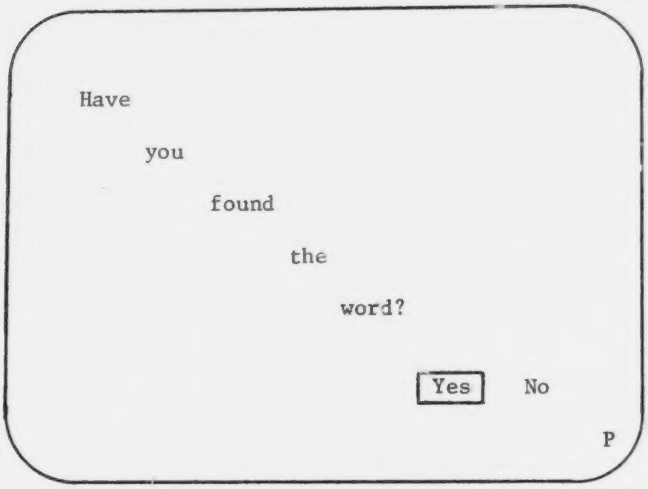
P



Do you want more time?

Yes No

P



Have

you

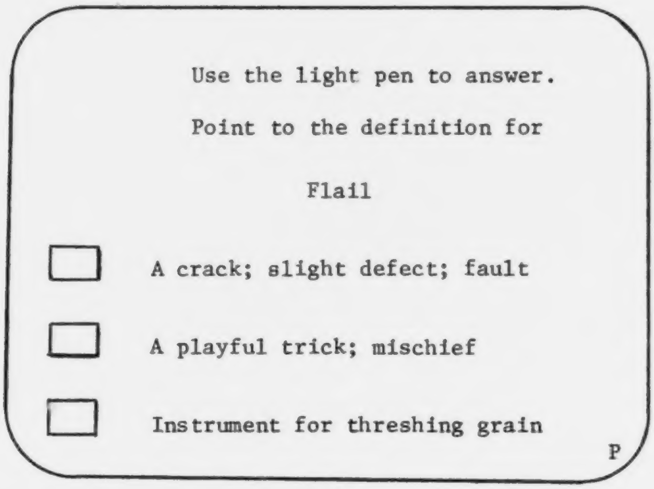
found

the

word?

Yes No

P



Use the light pen to answer.

Point to the definition for

Flail

☐ A crack; slight defect; fault

☐ A playful trick; mischief

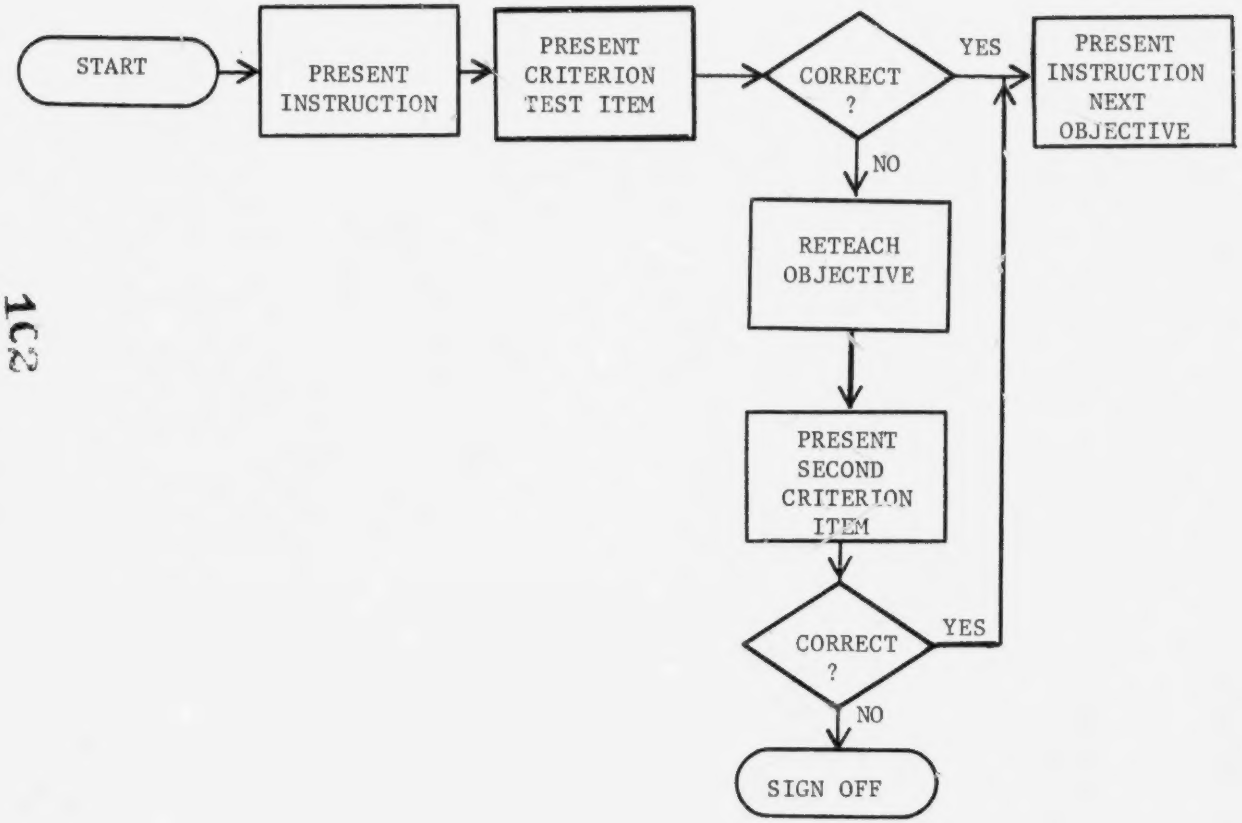
☐ Instrument for threshing grain

P

Mode of Presentation

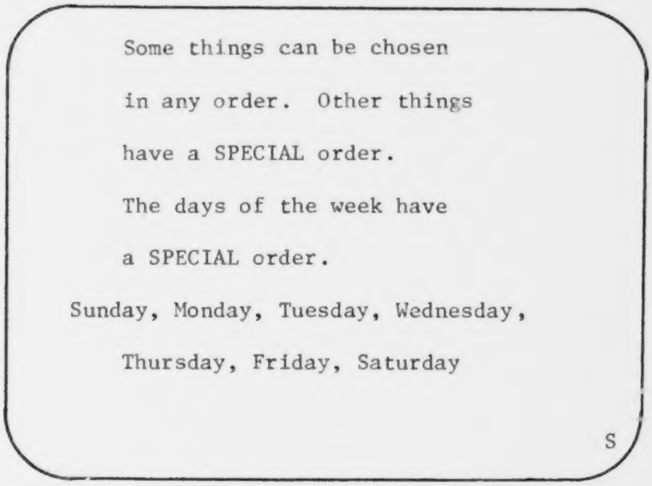
The student in this diagnostic and tutorial program interacts with a terminal consisting of an instructional display with keyboard, light pen, and image projector. Following diagnosis, the student receives instruction and practice in dictionary skills.

WORD SEARCH - INSTRUCTIONAL STRATEGY

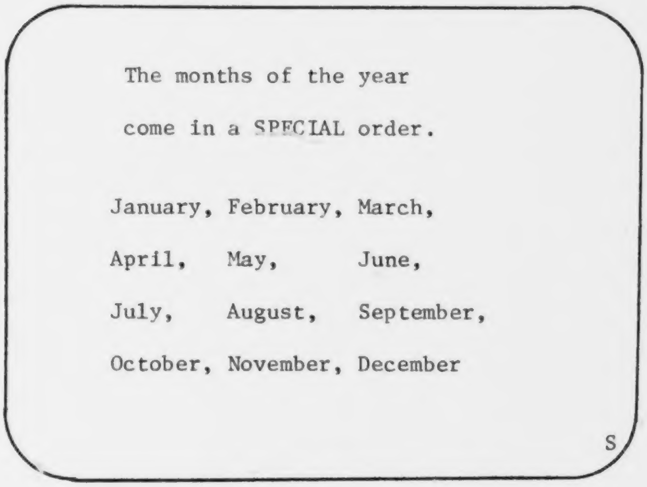


START
PRESENT INSTRUCTION
PRESENT CRITERION TEST ITEM
CORRECT ?
YES
PRESENT INSTRUCTION NEXT OBJECTIVE
NO
RETEACH OBJECTIVE
PRESENT SECOND CRITERION ITEM
CORRECT ?
YES
NO
SIGN OFF

Sample Section of Program

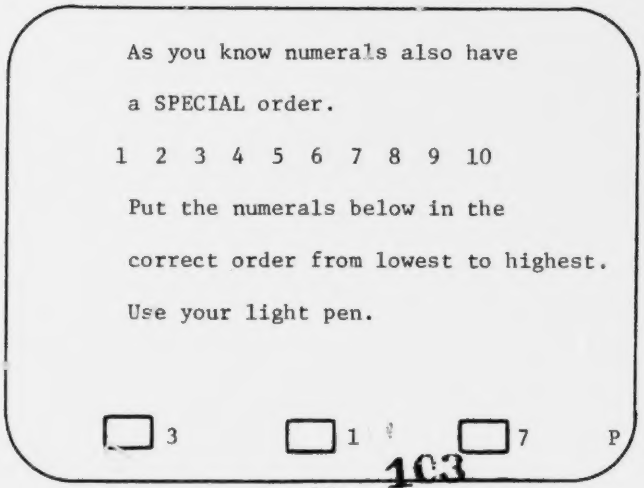

Some things can be chosen
in any order. Other things
have a SPECIAL order.
The days of the week have
a SPECIAL order.
Sunday, Monday, Tuesday, Wednesday,
Thursday, Friday, Saturday

S


The months of the year
come in a SPECIAL order.

January, February, March,
April, May, June,
July, August, September,
October, November, December

S


As you know numerals also have
a SPECIAL order.
1 2 3 4 5 6 7 8 9 10
Put the numerals below in the
correct order from lowest to highest.
Use your light pen.

☐ 3 ☐ 1 ☐ 7 P

The alphabet has a SPECIAL order.

A B C D E F G H I J K L M

N O P Q R S T U V W X Y Z

Use the light pen to point to the letter that should come last in the list below.

☐ R ☐ O ☐ S

P

Do you know what the word LAST means?

On the image projector there is a picture of a family.

The LAST person in the picture is the father.

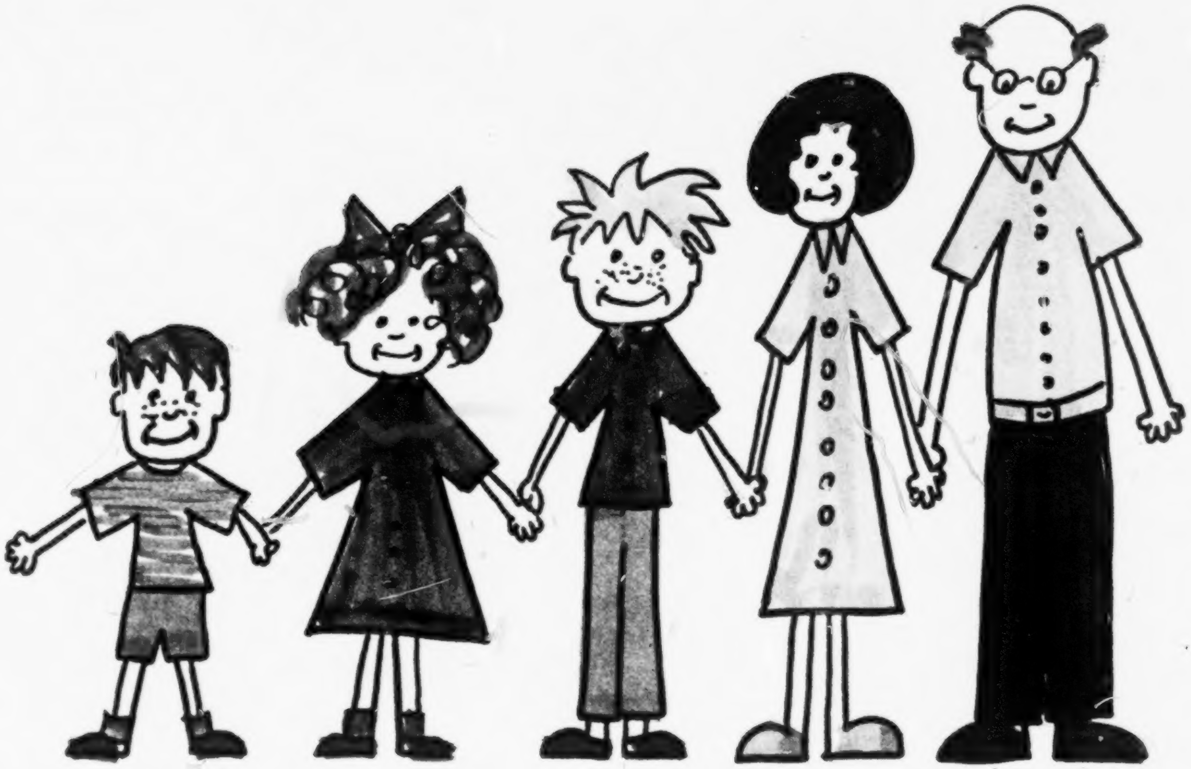
S

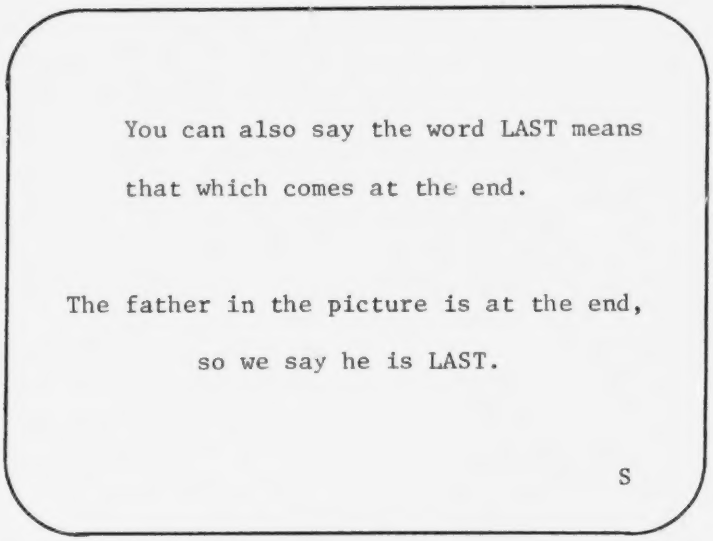
The father is the LAST person in the picture. He is LAST because he comes after all the others.

The word LAST means -

That which comes after all the others.

S

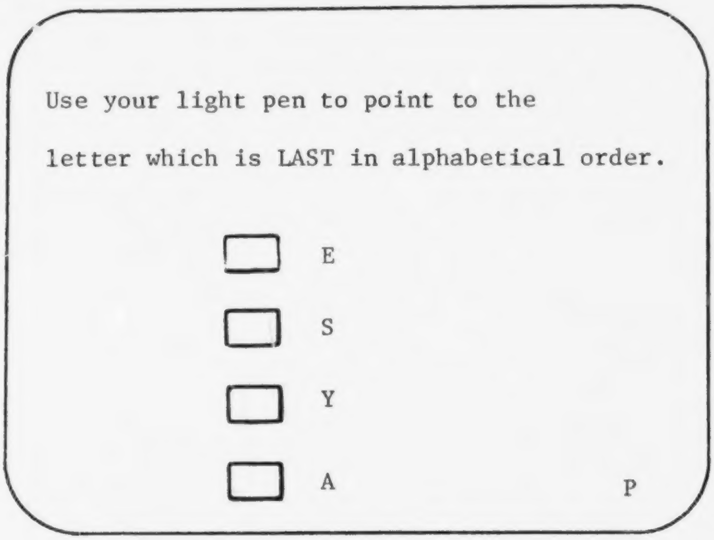




You can also say the word LAST means
that which comes at the end.

The father in the picture is at the end,
so we say he is LAST.

S



Use your light pen to point to the
letter which is LAST in alphabetical order.

☐ E
☐ S
☐ Y
☐ A

P

Comments

Approximately two-thirds of the segment has been coded. The remainder of the program is in the developmental stage and initial use of the segment is planned for late fall, 1971.

e. EXPANDING NUMERALS

Need

This concept was identified for development by Nita Axley, a supporting teacher, who felt it was an important concept not possessed by many fourth graders.

Terminal Objective

Given a three-place numeral, the student constructs the expanded form, illustrating place value: EXAMPLE: 325 = (3 x 100) + (2 x 10) + (5 x 1)

Criterion Item

Type in the correct digits

to show the expanded form

for the following numeral.

If you do not want a digit where the

box stops, press the space bar.

937 = (x   ) + (x   ) + (x   )

Entering Behaviors

1. Given a series of like numerals expressed as an addition number sentence, the student rewrites it as a multiplication number sentence.
2. The student identifies the value of the positions of the digits in a three-place numeral.
3. The student identifies the meaning of the digits in a three-place numeral.
4. The student expands by addition the meaning of the digits in a three-place numeral.

Enabling Behaviors

1. Student identifies the number sentence having two operations with correct placement of parentheses to show separation of operations.

   (1) $(2 \times 3)+4 = 10$
   (2) $2 \times (3+4) = 14$

2. Given a number sentence having two operations, without parentheses, the student constructs parentheses to show separation of operations for the answer given.

3. Student identifies the expanded form of a two-place numeral having correct placement of parentheses to show separation of operations.

4. Given the expanded form of a two-place numeral, without parentheses, the student constructs parentheses to show separation of operations.

5. The student identifies the number sentence which shows that a one-place numeral = n x 1.

6. The student constructs the numeral which shows that a one-place number = ☐ x 1.

7. The student constructs the numeral which shows that a one-place number = n x ☐.

8. Given a one-place numeral the student constructs numerals which show that n = n x 1.

9. The student identifies the number sentence which shows that a two-place numeral with zero in the ones' place = n x 10.

10. Given a two-place numeral with zero in the one's place, the student constructs the numeral which shows that n = ☐ x 10.

11. Given a two-place numeral with zero in the ones' place, the student constructs the numeral which shows that n = n x ☐.

12. Given a two-place numeral with zero in the ones' place, the student constructs the numerals which show that n = n x 10.

13. The student identifies the number sentence which shows that a three-place numeral with zero in the tens' place and zero in the ones' place = n x 100.

14. Given a three-place numeral with zero in the tens' place and zero in the ones' place, the student constructs the numeral which shows that n = ☐ x 100.

15. Given a three-place numeral with zero in the tens' place and zero in the ones' place, the student constructs the numeral which shows that n = n x ☐.

16. Given a three-place numeral with zero in the tens' place and zero in the ones' place, the student constructs numerals which show that n = n x 100.

17. The student identifies the number sentence which shows that a two-place numeral = $(n \times 10) + (n \times 1)$.

18. The student constructs the numerals which show that a two-place numeral = $(\square \times 10) + (\square \times 1)$.

19. The student constructs the numerals which show that a two-place numeral = $(a \times \square) + (b \times \square)$.

20. Given a two-place numeral, the student constructs the expanded form to show place value.

    Example: $25 = (2 \times 10)+(5 \times 1)$

21. Student identifies expanded form of a three-place numeral having correct placement of parentheses to show separation of operations.

22. Given the expanded form of a three-place numeral, without parentheses, the student constructs parentheses to show separation of operations.

23. The student identifies the number sentence which shows that a three-place numeral = $(\square \times 100) + (\square \times 10) + (\square \times 1)$.

24. The student constructs the numerals which show that a three-place numeral = $(a \times \square) + (b \times \square) + (c \times \square)$.

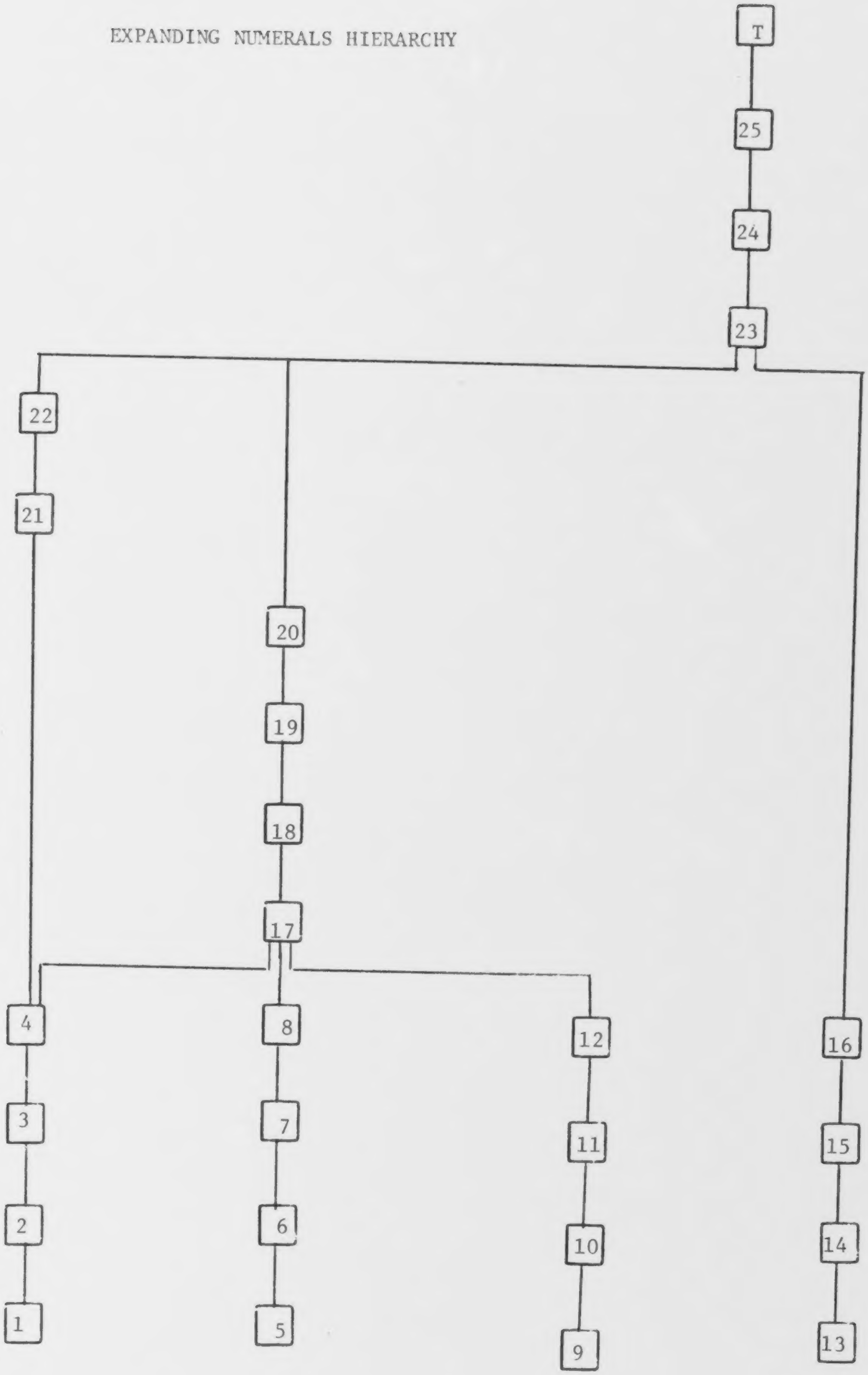
25. Given a three-place numeral, the student constructs the expanded form to show place value.

    Example: $562 = (5 \times 100) + (6 \times 10) + (2 \times 1)$

Comments

While planned as a tutorial segment, in actuality, the program as written is an ordered sequence of drills. There are no plans to code this material at the present time.

EXPANDING NUMERALS HIERARCHY


T
25
24
23
22
21
20
19
18
17
4
3
2
1
8
7
6
5
12
11
10
9
16
15
14
13

f. SIGN-ON FRACTIONS

Need

Teachers in the upper elementary grades requested a program in the computational skills of fractions. Upon analysis of the behaviors involved in the addition and subtraction of fractions, the teacher-specialist found a need to revise the sequence of skills from that normally used in the classroom.

Description

A sequence of 39 drills, 19 providing practice in the addition of fractions and 20 providing practice in the subtraction of fractions, was designed for upper elementary school students by teacher specialist Beverly Sangston.

Sign-On Fractions may be used according to the author-arranged sequence, or individual drills may be selected by the student or teacher.

This program was coded in COURSEWRITER II by William Swisher and Michael Dyson.

Terminal Objectives

Given two fractions or two mixed numerals with unlike denominators, for which the lowest common denominator is not the denominator or the product of the denominators, the student writes the sum in its simplest form.*

Given two mixed numerals or a mixed numeral and a fraction with unlike denominators, for which the lowest common denominator is not the denominator or the product of the denominators, the student writes the difference in its simplest form.*

Program Sequence

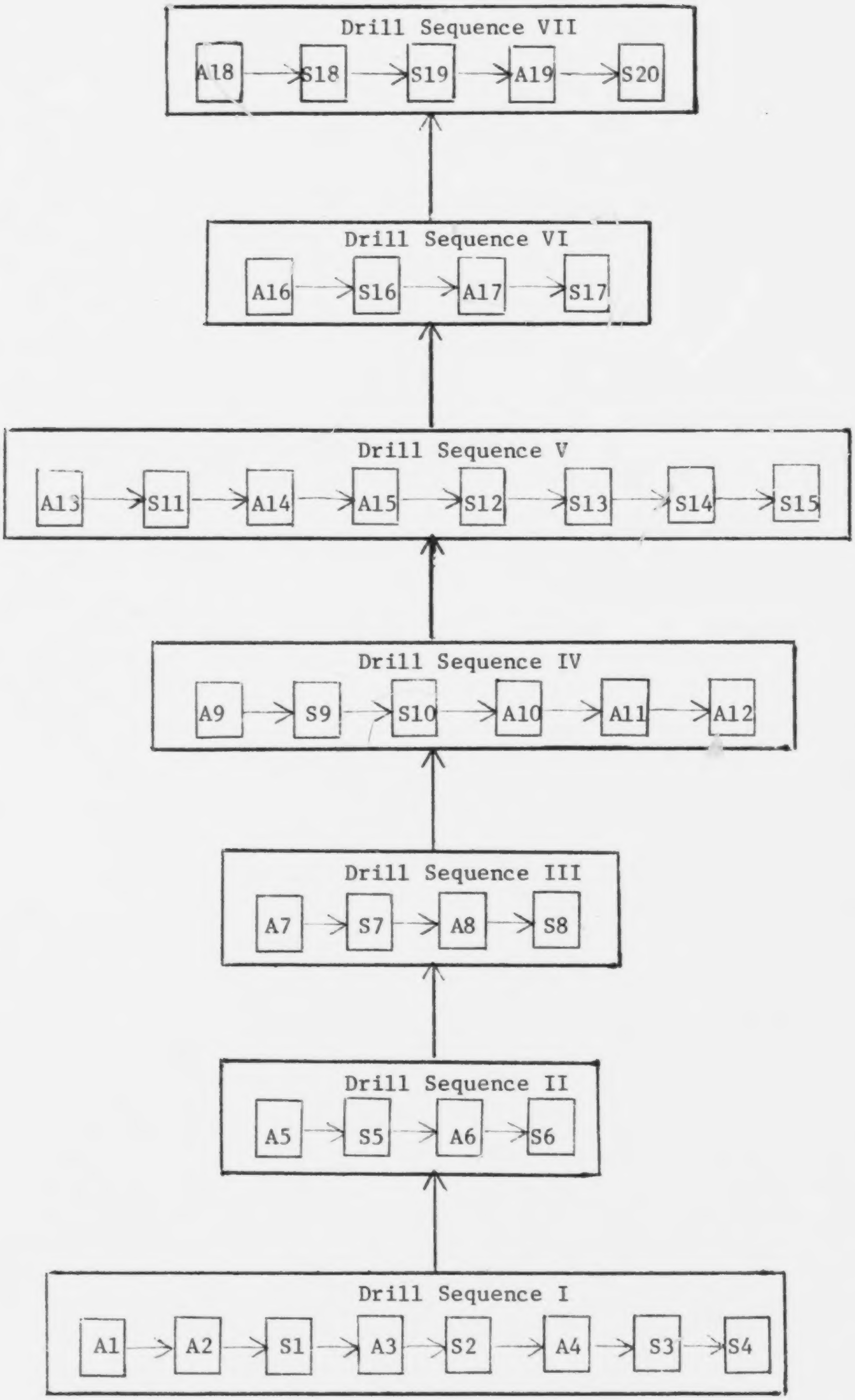
The 39 addition and subtraction drills are grouped according to related objectives and increasing difficulty within seven drill sequences. Refer to the sequence chart for the order in which the individual addition and subtraction drills are presented in the author-arranged program.

---

*The whole numbers do not exceed 9, and the denominators of the fractions do not exceed 16. Only two addends are involved in sums.

PROGRAM SEQUENCE

SIGN-ON FRACTIONS


Drill Sequence VII
A18
S18
S19
A19
S20
Drill Sequence VI
A16
S16
A17
S17
Drill Sequence V
A13
S11
A14
A15
S12
S13
S14
S15
Drill Sequence IV
A9
S9
S10
A10
A11
A12
Drill Sequence III
A7
S7
A8
S8
Drill Sequence II
A5
S5
A6
S6
Drill Sequence I
A1
A2
S1
A3
S2
A4
S3
S4

Entering Behaviors

Before entering drill sequence I, the student will be tested on the following fractional concepts:

> Given an illustration of a plane figure divided into less than ten equal parts with one or more of the parts shaded, the student writes the fraction represented by the shaded parts.
>
> Given an illustration consisting of 12 or less identical objects some of which are enclosed by line segments, the student writes the fraction represented.

Five items on each objective are presented. The student must answer correctly at least four in each group in order to enter the drills.

Sequence I

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Their sums or differences do not require simplication.

In this sequence, problems presented are designed to build proficiency in these skills:

A1 Given a whole number and a fraction, the student writes the sum.

2 + 3/8 = 2 3/8

A2 Given two fractions whose sum is less than one, the student writes the sum.

1/5 + 3/5 = 4/5

S1 Given two fractions, the student writes the difference.

4/5 - 1/5 = 3/5

A3 Given a mixed numeral and a fraction, the student writes the sum.

2 3/7 + 2/7 = 2 5/7

S2 Given a mixed numeral and a fraction, the student writes the difference.

2 4/5 - 1/5 = 2 3/5

A4 Given two mixed numerals, the student writes the sum.

3 1/5 + 2 2/5 = 5 3/5

S3 Given two mixed numerals, the student writes the difference.

2 4/5 - 1 3/5 = 1 1/5

S4 Given two mixed numerals whose difference is a whole number, the student writes the difference.

2 4/5 - 1 4/5 = 1

There is an individual drill grouping of ten problems for each objective. See the strategy chart.

Sequence II

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Sums are expressed as fractional names for whole numbers prior to being simplified. Differences do not require simplication.

Drills for sequence II are for increasing competency in these skill areas:

A5 Given two fractions, the student writes the sum.

3/4 + 1/4 = 4/4 = 1

S5 Given the whole number 1 and a fraction, the student writes the difference.

1 - 1/3 = 2/3

A6 Given two mixed numerals, the student writes the sum.

3 3/4 + 1 1/4 = 4 4/4 = 5

S6 Given a whole number greater than 1 and a fraction, the student writes the difference.

6 - 3/5 = 5 2/5

Sequence III

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. The sums need to be rewritten as mixed numerals.

The objectives involved in the drills for this sequence are:

A7 Given two fractions, the student writes the sum.

4/5 + 3/5 = 7/5 = 1 2/5

S7 Given a mixed numeral and a fraction, the student writes the difference.

1 2/5 - 4/5 = 3/5

A8 Given two mixed numerals, the student writes the sum.

2 4/7 + 2 5/7 = 4 9/7 = 5 2/7

S8 Given two mixed numerals, the student writes the difference.

7 2/5 - 5 4/5 = 1 3/5

Sequence IV

All fractional numerals and mixed numerals in this drill sequence have like denominators and are in simplest form. Their sums or differences must be simplified.

Objectives included in this sequence are:

A9 Given two fractions whose sum is less than one, the student writes the sum.

1/4 + 1/4 = 2/4 = 1/2

S9 Given two fractional numerals whose difference is less than one, the student writes the difference.

8/9 - 5/9 = 3/9 = 1/3

S10 Given two mixed numerals whose difference is greater than one, the student writes the difference.

9 5/6 - 3 1/6 = 6 4/6 = 6 2/3

A10 Given two fractions whose sum is greater than one, the student writes the sum.

3/4 + 3/4 = 6/4 = 3/2 = 1 1/2

A11 Given two mixed numerals with the sum of their fractional numerals less than one, the student writes the sum of the mixed numerals.

2 3/8 + 1 1/8 = 3 4/8 = 3 1/2

A12 Given two mixed numerals with the sum of their fractional numerals greater than one, the student writes the sum of the mixed numerals.

2 7/8 + 3 5/8 - 5 12/8 = 5 3/2 = 6 1/2

Sequence V

All fractional numerals and mixed numerals in this drill sequence are in simplest form and have unlike denominators. The lowest common denominator in the problems is one of the denominators. The sums and differences may need to be simplified or rewritten as mixed numerals.

Objectives for this sequence are:

A13 Given two fractions, the student writes the sum.

1/2 + 1/4 = 3/4

S11 Given two mixed numerals, the student writes the difference.

7 1/2 - 3 1/4 = 4 1/4

A14 Given two fractions whose sum is greater than one, the student writes the sum.

5/8 + 1/2 = 9/8 = 1 1/8

A15 Given two fractions, the student writes the sum which requires both simplifying and rewriting as a mixed numeral.

2/3 + 5/6 = 9/6 = 3/2 = 1 1/2

S12 Given two mixed numerals, the student writes the difference, which requires simplifying.

3 5/6 - 2 1/2 = 1 2/6 = 1 1/3

S13 Given a mixed numeral and a fraction whose difference is less than one, the student writes the difference.

1 1/4 - 1/2 = 3/4

S14 Given a mixed numeral and a fraction, the student writes the difference, where the difference is greater than one.

9 1/3 - 5/9 = 8 7/9

S15 Given two mixed numerals, the student writes the difference.

3 1/4 - 1 1/2 = 1 3/4

Sequence VI

All fractional and mixed numerals in this drill sequence have unlike denominators, and the lowest common denominator in the problems is the product of the denominators. Sums may need to be rewritten as mixed numerals. Differences do not require simplification.

Objectives included in this sequence are:

A16 Given two fractions whose sum is less than one, the student writes the sum.

1/4 + 1/3 = 7/12

S16 Given two mixed numerals whose difference is less than one, the student writes the difference.

2 2/3 - 2 1/4 = 5/12

A17 Given two fractions or two mixed numerals whose fractional sum is greater than one, the student writes the sum.

4/5 + 1/2 = 13/10 = 1 3/10

S17 Given two mixed numerals with the first mixed numeral requiring renaming after the common denominator has been calculated, the student writes the difference.

3 1/4 - 1 2/3 = 1 7/12

Sequence VII

All fractional numerals and mixed numerals in this drill sequence have unlike denominators and their lowest common denominator is not one of the denominators or their product. Sums may need to be rewritten as mixed numerals.

Included in this sequence are:

A18 Given two fractions whose sum is less than one, the student writes the sum.

3/10 + 3/8 = 27/40

S18 Given two fractions, the student writes the difference.

7/10 - 3/8 = 13/40

S19 Given two mixed numerals, the student writes the difference.

6 7/8 - 2 5/6 = 4 1/24

A19 Given two fractions or two mixed numerals whose fractional sum is greater than one, the student writes the sum.

1/4 + 9/10 = 23/20 = 1 3/20

S20 Given two mixed numerals with the first mixed numeral requiring renaming after the common denominator has been calculated, the student writes the difference.

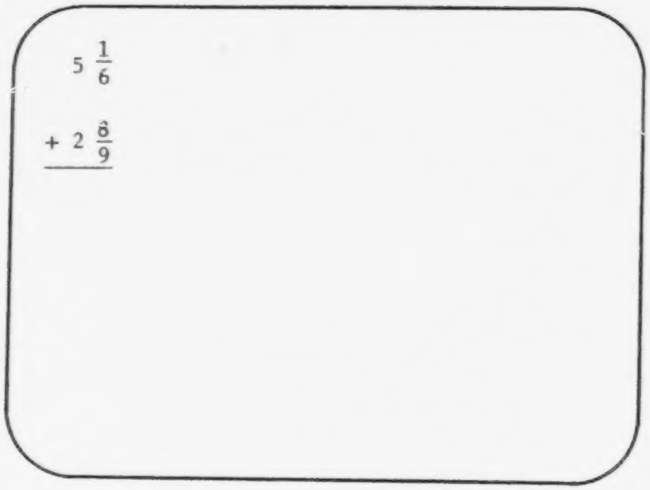
7 1/9 - 2 1/6 = 4 17/18

Mode of Presentation

This program can be presented on an IBM 1510 Instructional Display or on an IBM 1518 Typewriter.

Sample Section of Program

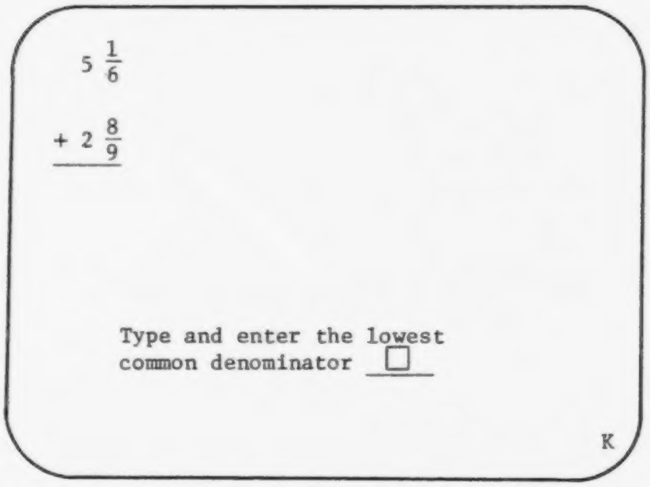
1. Problem is presented



$5\frac{1}{6}$

$\underline{+\ 2\frac{8}{9}}$

2. Student names the lowest common denominator



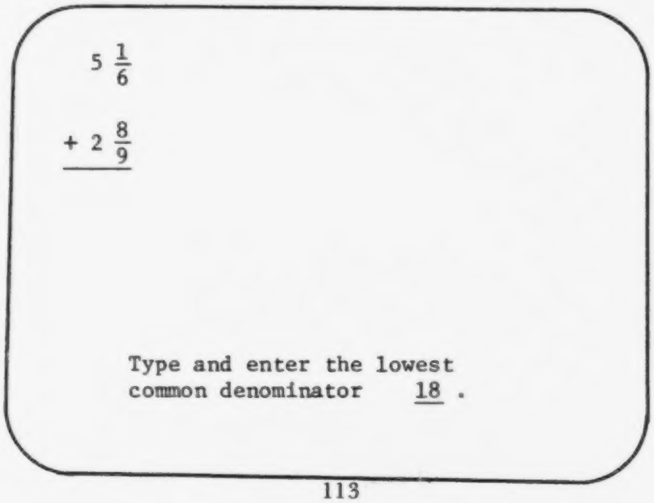
$5\frac{1}{6}$

$\underline{+\ 2\frac{8}{9}}$

Type and enter the lowest
common denominator ☐

K

3. Student types response; response is evaluated



$5\frac{1}{6}$

$\underline{+\ 2\frac{8}{9}}$

Type and enter the lowest
common denominator 18 .

4. Student names an equivalent fraction

$$5\frac{1}{6} = 5\frac{\square}{18}$$

$$\underline{+\ 2\frac{8}{9} =}$$

Name the equivalent fraction.

K

5. Student names the other equivalent fraction

$$5\frac{1}{6} = 5\frac{3}{18}$$

$$\underline{+\ 2\frac{8}{9} = 2\frac{\square}{18}}$$

Name the equivalent fraction.

K

6. Student adds the whole numbers

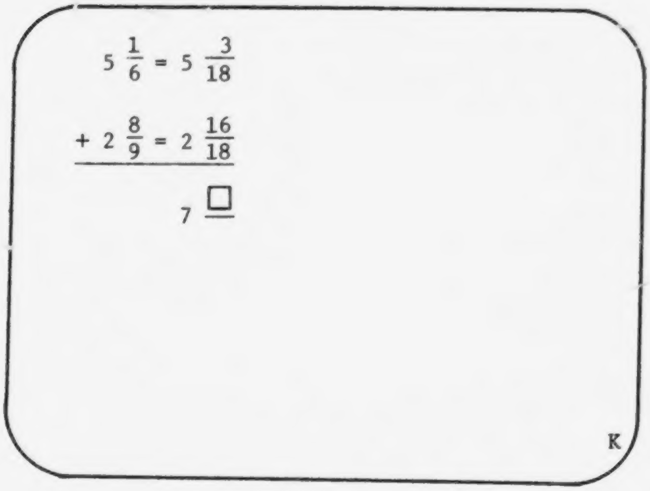
$$5\frac{1}{6} = 5\frac{3}{18}$$

$$\underline{+\ 2\frac{8}{9} = 2\frac{16}{18}}$$

$$\square\,\text{—}$$

K

7. Student adds the numerators



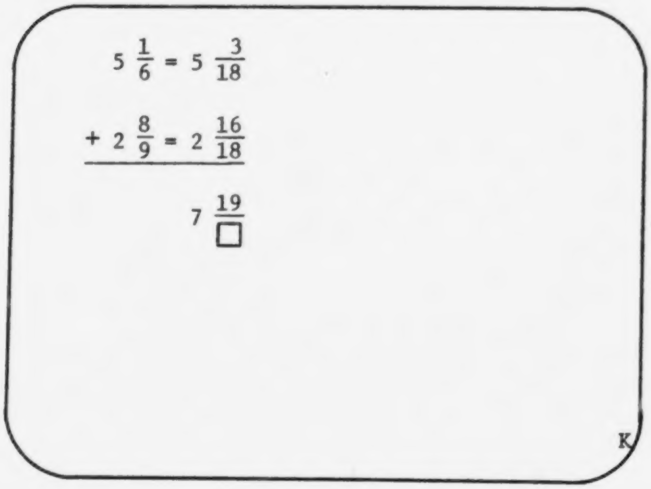
$$5\tfrac{1}{6} = 5\tfrac{3}{18}$$

$$\underline{+\ 2\tfrac{8}{9} = 2\tfrac{16}{18}}$$

$$7\tfrac{\square}{\ }$$

K

8. Student types the denominator



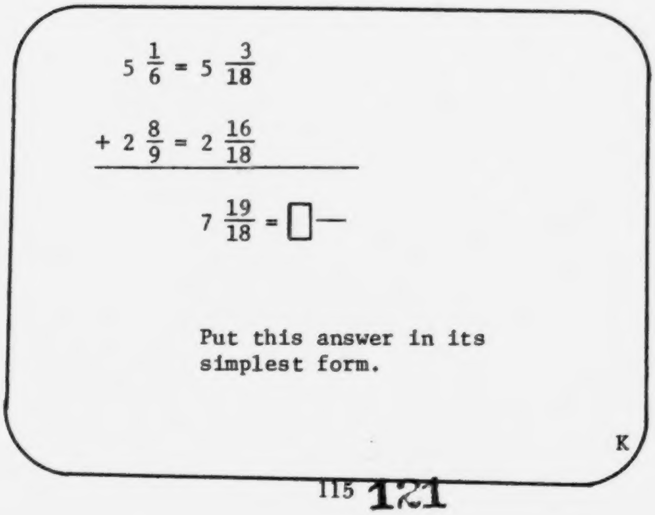
$$5\tfrac{1}{6} = 5\tfrac{3}{18}$$

$$\underline{+\ 2\tfrac{8}{9} = 2\tfrac{16}{18}}$$

$$7\tfrac{19}{\square}$$

K

9. Student simplifies answer; types the whole number



$$5\tfrac{1}{6} = 5\tfrac{3}{18}$$

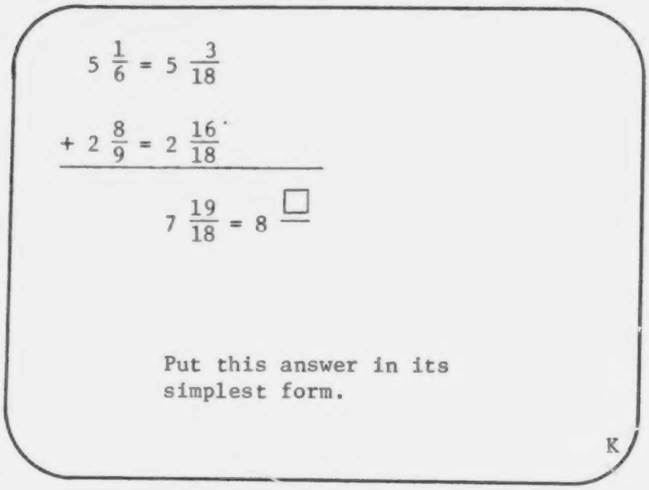
$$\underline{+\ 2\tfrac{8}{9} = 2\tfrac{16}{18}}$$

$$7\tfrac{19}{18} = \square\tfrac{\ }{\ }$$

Put this answer in its simplest form.

K

10. Student simplifies answer; types the numerator



$$5\,\frac{1}{6} = 5\,\frac{3}{18}$$

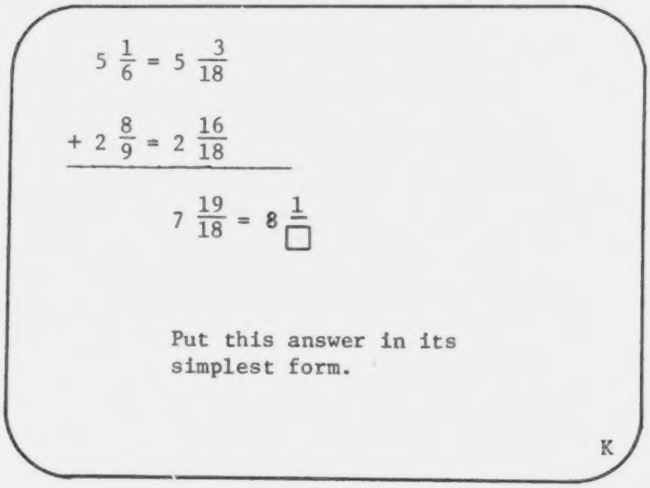
$$+\;2\,\frac{8}{9} = 2\,\frac{16}{18}$$

$$7\,\frac{19}{18} = 8\,\frac{\square}{}$$

Put this answer in its simplest form.

K

11. Student simplifies answer; types the denominator



$$5\,\frac{1}{6} = 5\,\frac{3}{18}$$

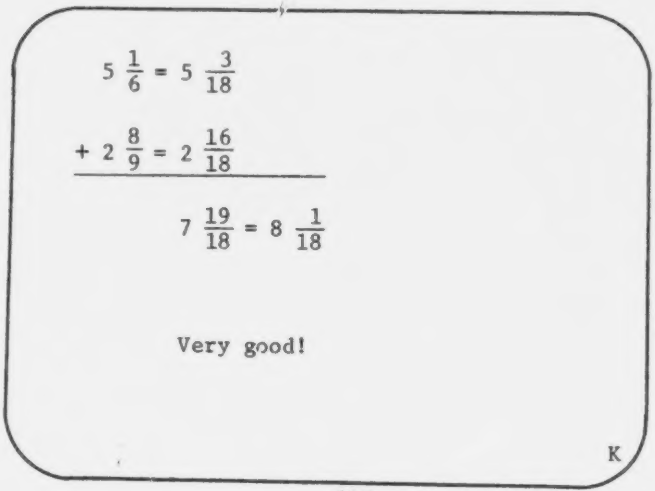
$$+\;2\,\frac{8}{9} = 2\,\frac{16}{18}$$

$$7\,\frac{19}{18} = 8\,\frac{1}{\square}$$

Put this answer in its simplest form.

K

12. Student's answer is evaluated; receives response for a correct answer.



$$5\,\frac{1}{6} = 5\,\frac{3}{18}$$

$$+\;2\,\frac{8}{9} = 2\,\frac{16}{18}$$

$$7\,\frac{19}{18} = 8\,\frac{1}{18}$$

Very good!

K

Comments

While this program was authored for a target population of upper elementary school students, the program will be useful with some junior and senior high school students

Pilot testing of this program occurred during the spring of 1971. The program is still in the developmental stages; a series of concept and diagnostic tests will be included in a new version.

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2. JUNIOR HIGH SCHOOL SCIENCE

by

B. Jean Wastler

The Design Team

a. Entry

b. Measuring With the Vernier Caliper

c. Alkanes I

d. Alkanes II

e. Solutions

f. A Key to Identification

g. Getting to Know the Computer

THE DESIGN TEAM

Four science teachers, released from their classroom assignments one day every other week to develop CAI materials, worked with B. Jean Wastler, teacher specialist, who serves as leader of the junior high school science design team. Miss Wastler, who joined the CAI staff in August, 1968, received training on an informal basis. Prior to joining the staff, she had 12 years of teaching experience, including experience as a science resource teacher at Newport Junior High School. She received a B.S. in junior high education from Towson College, Maryland, and a M.Ed. in physical science from Pennsylvania State University. In addition, she has earned graduate credits in mathematics, public relations, administration and supervision, and science methods.

When the supporting teacher program was instituted, a letter was sent to all science teachers in the county indicating that part-time involvement in the CAI program was available. Telephone and on-site interviews were conducted by the design team leader for persons interested in joining the team.

Grace Tigani, biology teacher at Springbrook High School, was selected for the first training group because of her proficiency in teaching biology and her experience in authoring curriculum materials. Miss Tigani holds a B.S. and a M.A. degree and has 30 hours of additional graduate credit. She had 12 years of teaching experience at the time she joined the project. After completing the training course, she authored a lesson segment related to the biological and earth sciences.

Richard K. King, resource teacher at Eastern Junior High School, has worked with Montgomery County Public Schools science curriculum workshops which developed the science course of study for grades seven, eight, and nine. Twelve years of teaching experience, a B.S., and M.A., and 30 hours of additional graduate credits characterize his professional background. He has co-authored a modular instructional package involving measurement sciences and authored an organic chemistry segment.

Keith Johnson, a science teacher at Newport Junior High School, was also selected for the design team. His background encompassed nearly all aspects of science teaching. Mr. Johnson has returned to the classroom after 21 years experience as a science supervisor and 15 years as a classroom teacher. For 13 years as a supervisor, he taught a course entitled Recent Advances in Chemistry and Physics at American University. Holder of a B.S. and an M.A., Mr. Johnson's varied background includes concentrations of chemistry and electronics. His first design team contribution was in the field of chemistry.

Since the design team felt that computer-assisted instruction should involve beginning teachers as well as experienced teachers, Janet Frekko, a new teacher at Takoma Park Junior High School, was selected to join the science team. She holds a B.S. in biology and has co-authored a biological game package.

a. ENTRY

Assessment of Need

If the student station is to be employed successfully as an aid in individualized classroom instruction, the students using CAI must be able to proceed through a program with a minimum of help regarding operation of the equipment. This lesson segment capitalizes on student interest in the hardware to give instruction and practice in operation of the terminal. The program is designed for students in grades seven to nine. Junior high science students use this package first so that they master the operation of the terminal before their CAI science experiences. Other uses of the segment have included visitor orientations to the instructional system and demonstration of the terminal's capabilities.

Description of the Program

In this program, students work at the 1510 Instructional Display with light pen, using a student card which gives the specific procedures for initiating program use. This tutorial program was developed by B. Jean Wastler and coded into COURSEWRITER II by Anne Metzger and Sandra Bassett.

Terminal Objective

The student:

> Signs on the 1510 Instructional Display, proceeds through a lesson segment by using the keyboard and light pen to change displays, and then signs off.

Entering Behaviors

The student:

1. Tests at an IQ of 90 or above.
2. Demonstrates a sixth grade reading level.

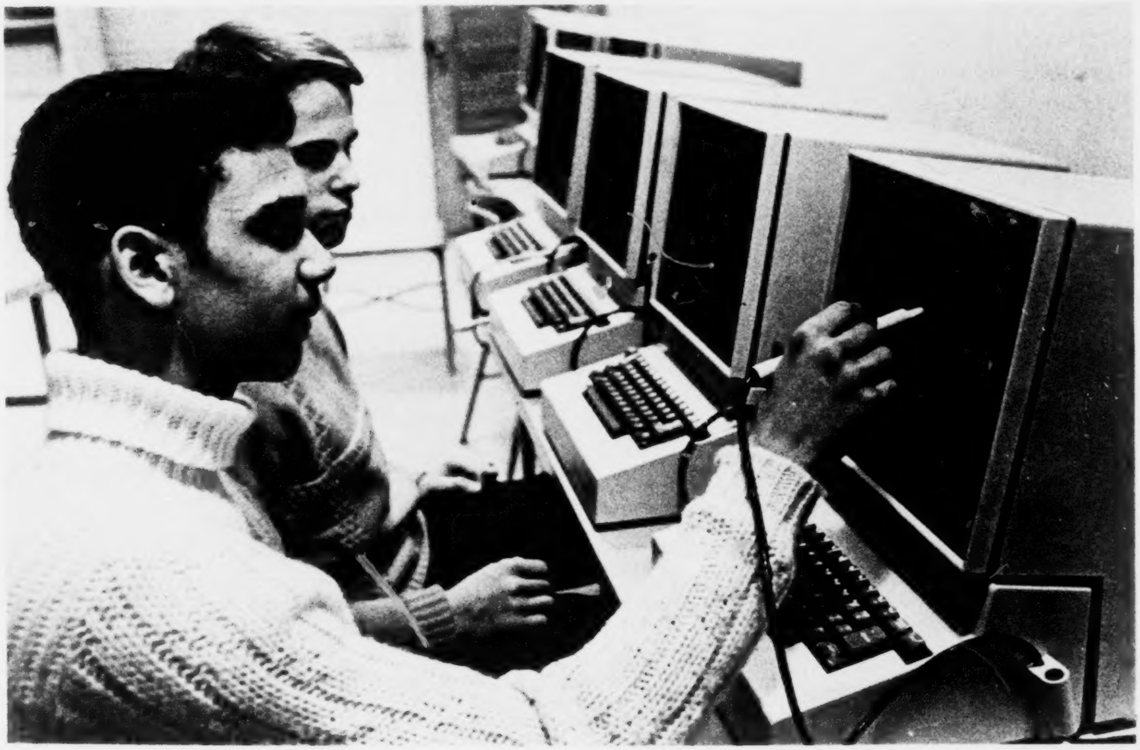
Enabling Objectives

The student:

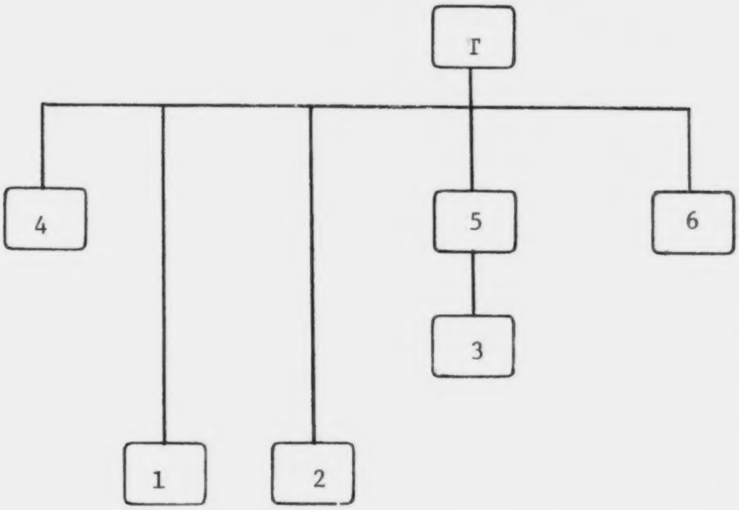
1. Uses the space bar of the keyboard to change a display (forward) when an *S* appears in the lower right corner of the screen.
2. Presses the light pen to an indicated area of the screen when a *P* appears in the lower right corner of the display.
3. Erases a keyboard response by depressing the alternate code key and the back space key simultaneously.
4. "Signs on" the 1510 Instructional Display by depressing the alternate code key and the index key simultaneously and typing "on entry/student number."

5. "Enters" a keyboard typed response when a *K* appears in the lower right corner of the screen by depressing the alternate code key and the space bar simultaneously.

6. "Signs off" the 1510 Instructional Display by depressing the alternate code key and the index key simultaneously and typing "off."



ENTRY - HIERARCHY



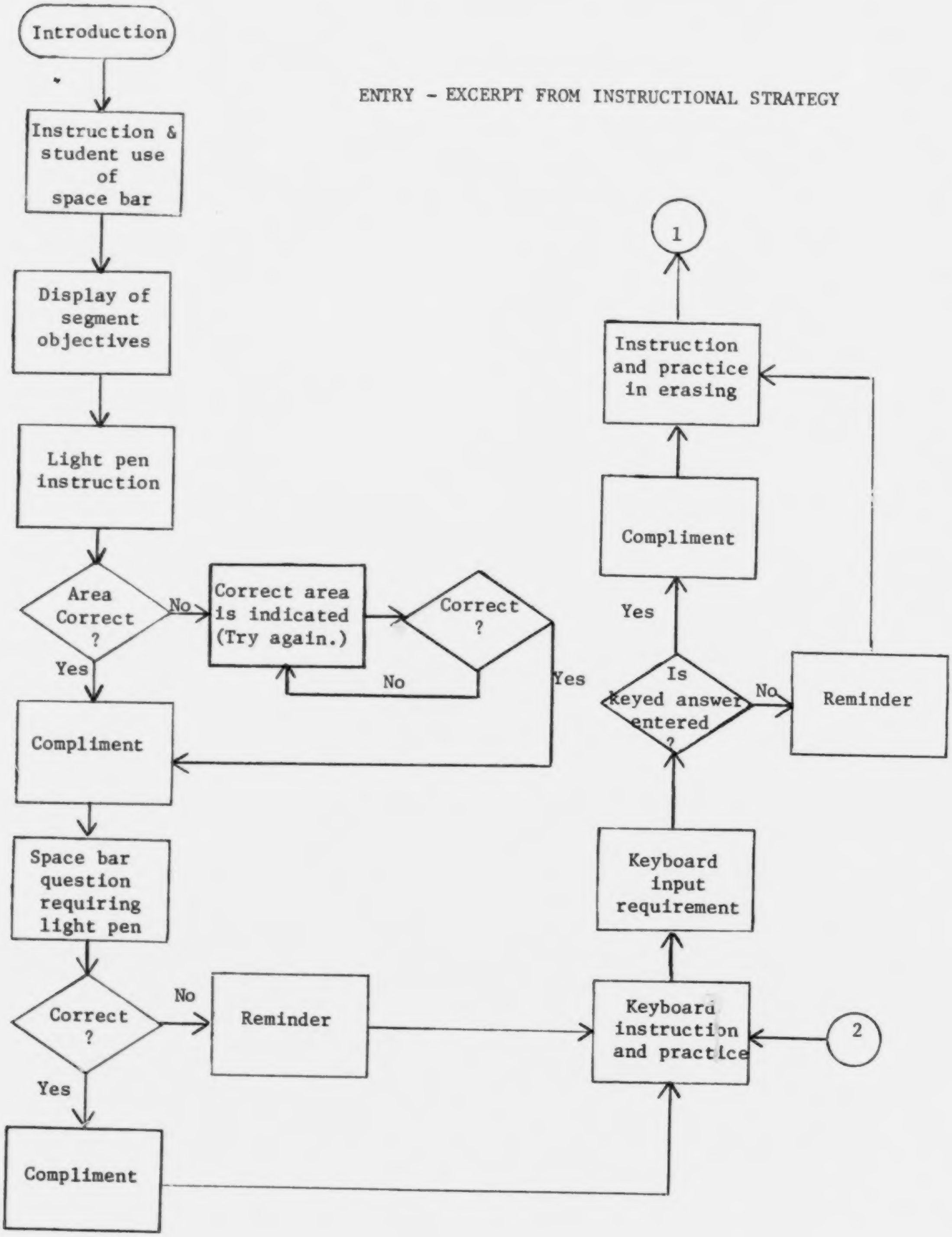
Pretest and Posttest

If the students have no previous experience with the 1500 Instructional System, usually no pretest is given. In cases where a pretest is needed, the posttest package for the lesson is employed. Observation by a proctor is necessary during the final stages of the posttest. The proctor must identify those students who cannot use the erase process since the computer is unable to perform this function. In addition, the computer system does not record the sign off procedure; thus the proctor should observe students performing these steps.

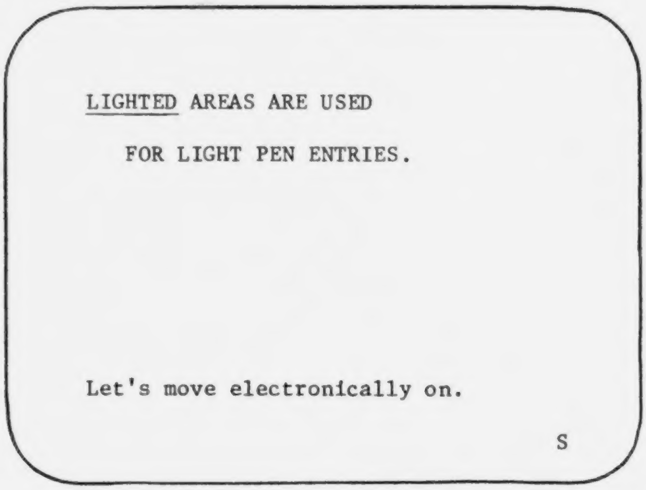
Mode of Presentation

Tutorial techniques were followed in the development of the instructional package. Some practice of the performance is provided after repetition of the proper response directions. Since the objectives of the program are dependent upon use of the instructional display, the primary stimulus used in this segment is the cathode ray tube. Each student is supplied with a card assigning a student number and providing information for signing on.

ENTRY - EXCERPT FROM INSTRUCTIONAL STRATEGY


Introduction
Instruction & student use of space bar
Display of segment objectives
Light pen instruction
Area Correct ?
No
Correct area is indicated (Try again.)
Correct ?
No
Yes
Yes
Compliment
Space bar question requiring light pen
Correct ?
No
Reminder
Yes
Compliment
Keyboard instruction and practice
2
Keyboard input requirement
Is keyed answer entered ?
No
Reminder
Yes
Compliment
Instruction and practice in erasing
1

Sample Section of Program

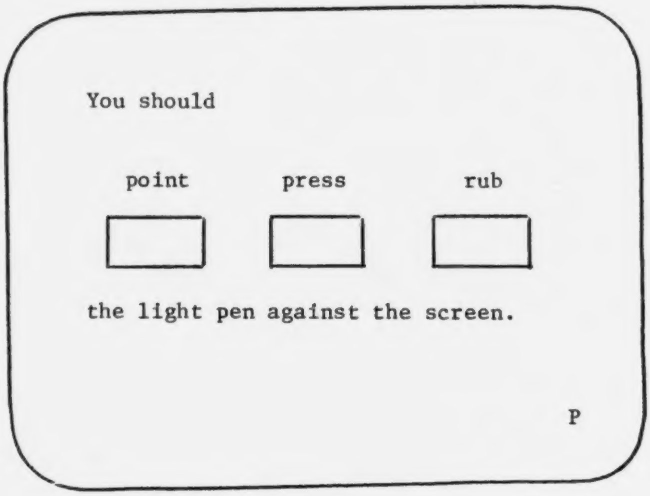


LIGHTED AREAS ARE USED

FOR LIGHT PEN ENTRIES.

Let's move electronically on.

S

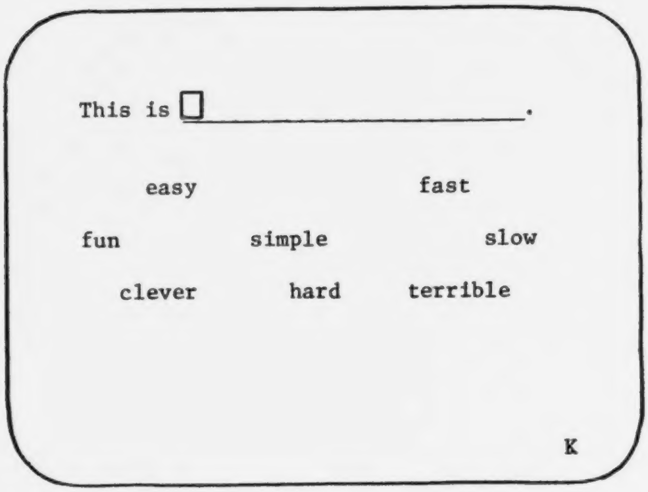


You should

point ☐ press ☐ rub ☐

the light pen against the screen.

P



This is ☐ ______________________.

easy fast

fun simple slow

clever hard terrible

K

Hooray! Welcome back.

You know how to sign on or you wouldn't be here.

Keep your student card. You will use the same number each time you sign on.

Go to the next display. S

FINE! You pressed the space bar to continue.

DO THAT AGAIN! (SPACE BARS TICKLE!)

S

Congratulations!

You have moved through

the ENTRY segment.

SIGN OFF. SEE YOU NEXT TIME.

Comments

This was the first lesson segment developed by the junior high school science design team leader. Student testing occurred in May, 1969. The program was used for junior high science students having CAI experiences in the school year 1969-70.

b. MEASURING WITH THE VERNIER CALIPER

Assessment of Need

Students come to the first unit in the MCPS ninth grade science curriculum with a diversity of backgrounds. Some students cannot measure with a ruler, while others are ready to meet objectives involving more complex measuring instruments. Measuring with the vernier caliper was therefore selected as an area for CAI lesson development.

Description of the Program

Introduction to the vernier caliper includes instruction on its use and practice in measuring with the instrument. The student, interacting with the 1510 Instructional Display, uses both the keyboard and light pen. In addition, he uses a vernier caliper, tin cans, a wooden block, and a student flipbook as aids in reaching two terminal objectives.

This program was developed by Richard K. King and B. Jean Wastler. It was coded into COURSEWRITER II by Anne Metzger.

Terminal Objectives

The student, when given a vernier caliper:

(1) States the vernier caliper's metric least count (precision).

(2) Measures to the nearest hundredth of a centimeter the depth, the inside, and the outside diameters of an open cylinder which has dimensions between 0.01 centimeters and 13.00 centimeters.

Entering Behaviors

1. Given a metric rule or a simulated metric rule, the student measures the linear dimensions of a given object with accuracy to a tenth of a centimeter.
2. Given a metric rule or an illustration of one, the student identifies the least count (precision) of the instrument.
3. Given a rule, or an illustration of a rule, with both English and metric scales, the student distinguishes the metric from the English.
4. Given an addition problem consisting of three addends: (1) one in whole centimeters between 0 and 13, (2) one in tenths of centimeters between .0 and .9, and (3) one in hundredths of centimeters between .00 and .09, the student adds them.

Enabling Objectives

1. Given a metric rule, a micrometer caliper, and a vernier caliper, or illustrations of the three, the student identifies the vernier caliper.
2. Given a vernier caliper or an illustration of one, the student identifies the fixed or parent scale.

3. Given a vernier caliper or an illustration of one, the student identifies the vernier scale.

4. Given a vernier caliper or an illustration of one, the student distinguishes between the vernier and the fixed or parent scale.

5. Given a vernier caliper or an illustration of one with metric and English scales, the student distinguishes one from the other.

6. Given a vernier caliper or an illustration of one, the student counts the spaces on the metric parent or fixed scale which occupy the same amount of space as the 10 metric divisions on the vernier scale.

7. Given a vernier caliper or an illustration of one, the student describes the metric relationships of the vernier scale to the fixed scale.

8. Given a vernier caliper or an illustration of one, the student identifies the outside calipers.

9. Given a vernier caliper or an illustration of one, the student identifies the inside calipers.

10. Given a vernier caliper or an illustration of one, the student identifies the depth gauge.

11. Given a vernier caliper or an illustration of one, the student distinguishes among the inside calipers, the outside calipers, and the depth gauge.

12. Given a linear measurement situation, the student identifies the part or parts of the vernier caliper to be used: inside calipers, outside calipers, or depth gauge.

13. Given a vernier caliper, the student adjusts its parts; or given an illustration of a vernier caliper, the student indicates adjustments.

14. Given a vernier caliper, the student adjusts it to make a measurement of outside dimensions; or given an illustration of a vernier caliper, the student indicates adjustments for a measurement of outside dimensions.

15. Given a vernier caliper or an illustration of one properly adjusted for measurement of an outside dimension, the student makes a reading of the fixed or parent scale.

16. Given a vernier caliper or an illustration of one adjusted for measurement of an outside dimension the student makes a reading of the vernier scale.

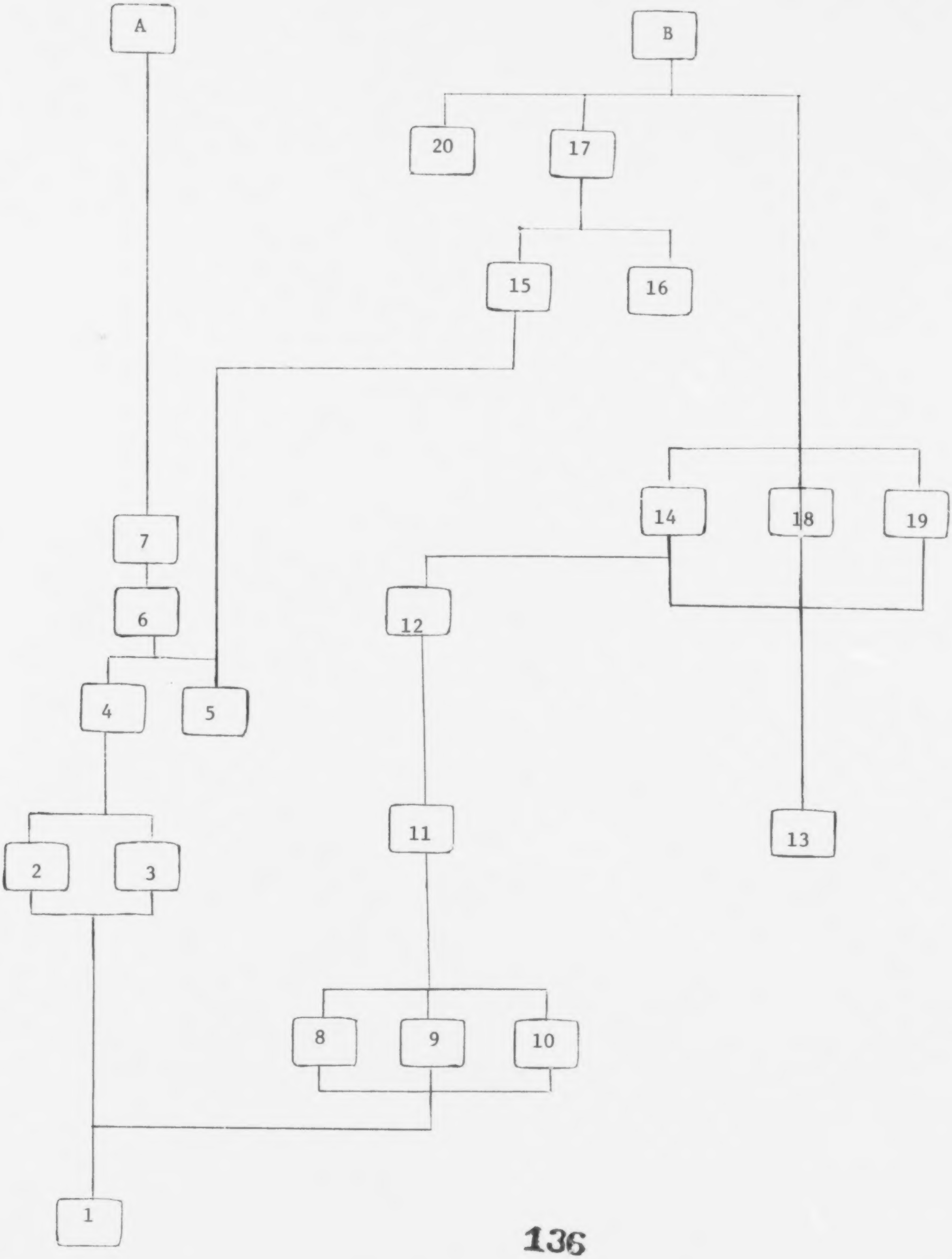
17. Given a vernier caliper or an illustration of one adjusted for measurement of an outside dimension, the student combines the parent or fixed scale reading and the vernier reading.

18. Given a vernier caliper, the student adjusts it to make a measurement of inside dimensions; or given an illustration of a vernier caliper, the student indicates the adjustments for measurement of inside dimensions.

19. Given a vernier caliper, the student adjusts it to make a measurement of depth; or given an illustration of a vernier caliper, the student indicates the adjustments for a measurement of depth.

20. Given a hollow metal cylinder, the student identifies a diameter.

VERNIER CALIPER - HIERARCHY


A
B
20
17
15
16
14
18
19
7
6
12
4
5
11
13
2
3
8
9
10
1

136

Pretest and Posttest

1. Looking at the vernier caliper in front of you, identify the least count or precision of this instrument in centimeters.

2. Using the vernier caliper, measure the outside diameter of the object labeled and state its measurements to the nearest hundredth of a centimeter.

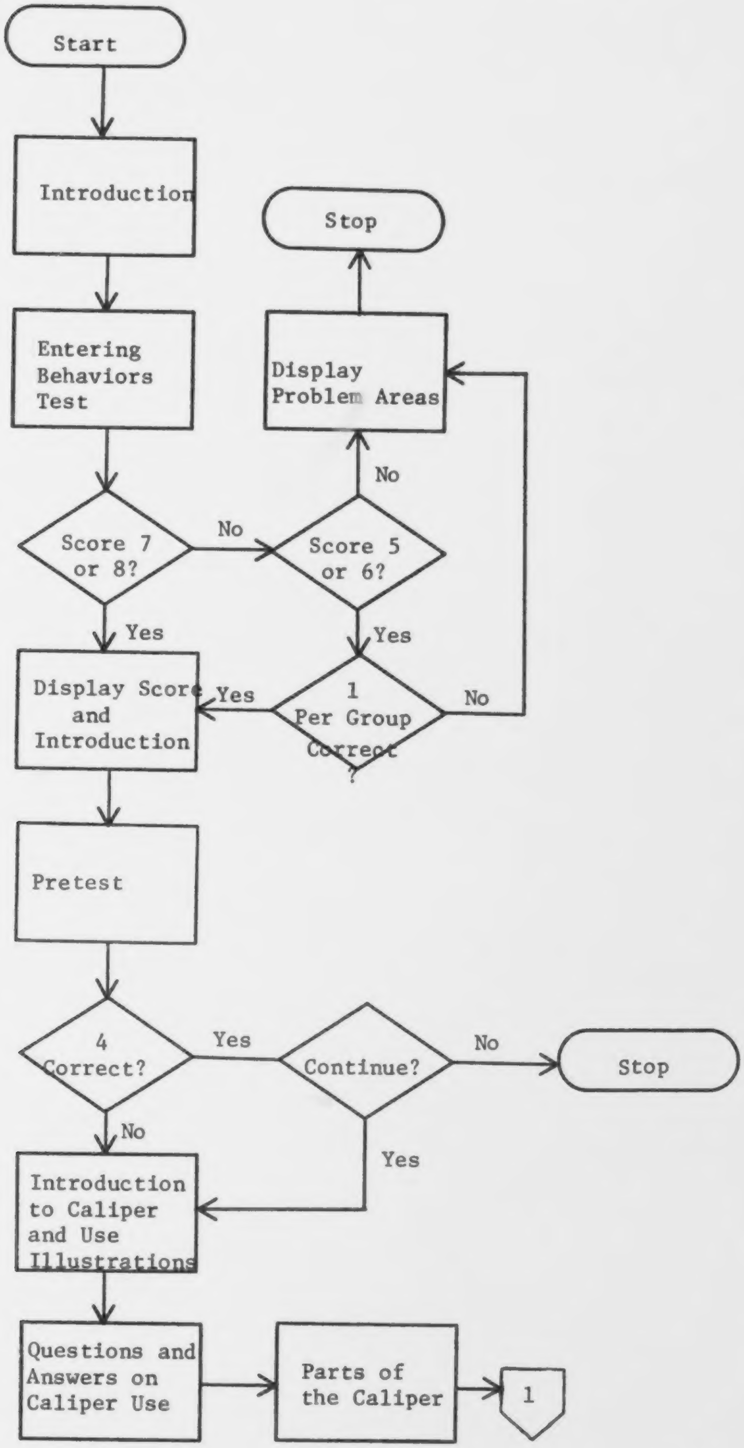
Mode of Presentation

Evaluation of the tutorial technique with simultaneous use of equipment at the terminal was kept in mind as the overall instructional strategy was developed. The vernier caliper and other materials are used in conjunction with the displays on the cathode ray tube. A linear tutorial program was decided upon; wrong answers are corrected immediately. Readings for outside measurements, inside measurements, and measurements of depth are all made in the same way. Initial instruction is given, followed by outlined procedures for the second measurement experience and help on the third measurement, only if needed.

Many of the illustrations used within this MIP would have taken up valuable computer dictionary space, thus flipbook materials were prepared.

I've developed a new philosophy.. I only dread one day at a time!!

VERNIER CALIPER - EXCERPT FROM INSTRUCTIONAL STRATEGY


Start
Introduction
Stop
Entering Behaviors Test
Display Problem Areas
No
Score 7 or 8?
No
Score 5 or 6?
Yes
Yes
Display Score and Introduction
Yes
1 Per Group Correct ?
No
Pretest
4 Correct?
Yes
Continue?
No
Stop
No
Yes
Introduction to Caliper and Use Illustrations
Questions and Answers on Caliper Use
Parts of the Caliper
1

Sample Section of Program

The vernier caliper is a measuring device that extends the accuracy of measurement to the nearest one-hundredth of a centimeter.

Look at page 8 in the flipbook.

S

Using the vernier caliper, measure the outside diameter of the object labeled A. What is its outside diameter measured to the nearest hundredth of a centimeter?

☐

K

Compare the number of spaces on the vernier with the number of spaces on the fixed scale.

How many spaces are there on the vernier scale? ☐ ______

K

Comment

Ninth grade students at Newport Junior High School used this program in the fall of 1969 as a part of their study of physical measurement.

c. ALKANES I

Assessment of Need

Students in the Montgomery County Public Schools ninth grade science program devote 12 weeks to the study of chemistry. The first six weeks include the study of inorganic chemistry, while organic chemistry comprises the last six weeks. Some students easily gain the concept of organic model construction, while other students fail to recognize the serial concept of compounds in the alkane series of hydrocarbons.

Description of the Program

Working at the 1510 Instructional Display with light pen, the student uses a molecular model kit to construct the first four compounds in the alkane series. The program guides his progress step-by-step from identification of the colors used to represent carbon and hydrogen to the construction of iso-butane.

Richard K. King authored this module. William Swisher, instructional programmer, coded the segment into COURSEWRITER II.

Terminal Objective

Given a molecular model kit, the student constructs and names models of the first four organic compounds in the alkane series of hydrocarbons, including the isomer of butane.

Entering Behaviors

(1) Given a periodic table of the elements, the student states the oxidation number or valence of the elements carbon and hydrogen; and (2) Given the number of electrons an element is able to given off, receive, or share during a chemical reaction, the student names the definition as the oxidation number or valence.

Enabling Objectives

1. Given a molecular model kit, the student identifes which color wooden ball represents the carbon atom.

2. Given a molecular model kit, the student identifies which color of wooden ball represents the hydrogen atom.

3. Given a molecular model kit or an illustration of one, the student states that the number of holes in the wooden balls is equal to the oxidation number, or valence, of an element.

4. Given a molecular model kit, the student identifies the short wooden peg for use in a model to combine carbon with any atom having a valence of one.

5. Given a molecular model kit, the student identifies the long wooden peg for use in a model to combine carbon with atoms having valences greater than one.

6. Given a molecular model kit or an illustration of one, the student distinguishes between the use of the long wooden pegs and the short wooden pegs in constructing organic models.

7. The student defines a hydrocarbon.

8. Given three molecular models or illustrations of three models, one having a single bond, one a double bond, and one a triple bond, the student distinguishes among a single, double, and triple bond.

9. The student defines a saturated hydrocarbon as one that has only single bonds between the carbon atoms or one which has all of its bonds satisfied.

10. Given molecular models or structural formulas of a saturated hydrocarbon and an unsaturated hydrocarbon or illustrations of these models, the student distinguishes between the saturated and the unsaturated hydrocarbons.

11. The student names saturated hydrocarbons alkanes.

12. Given a wooden ball representing a carbon atom and instructions to saturate it with models of the hydrogen atom, the student constructs the methane molecular model with the molecular model kit.

13. Given a model of the methane molecule or an illustration of a methane molecule, the student names it methane.

14. Given two wooden balls representing carbon atoms and instructions to saturate them to make one compound with models of hydrogen atoms, the student constructs the ethane molecular model with the molecular model kit.

15. Given a model of the ethane molecule or an illustration of an ethane molecule, the student names it ethane.

16. Given three wooden balls representing carbon atoms and instructions to saturate them with models of hydrogen atoms to form one compound, the student constructs the propane molecular model with the molecular model kit.

17. Given a model of propane or an illustration of a propane molecule, the student names it propane.

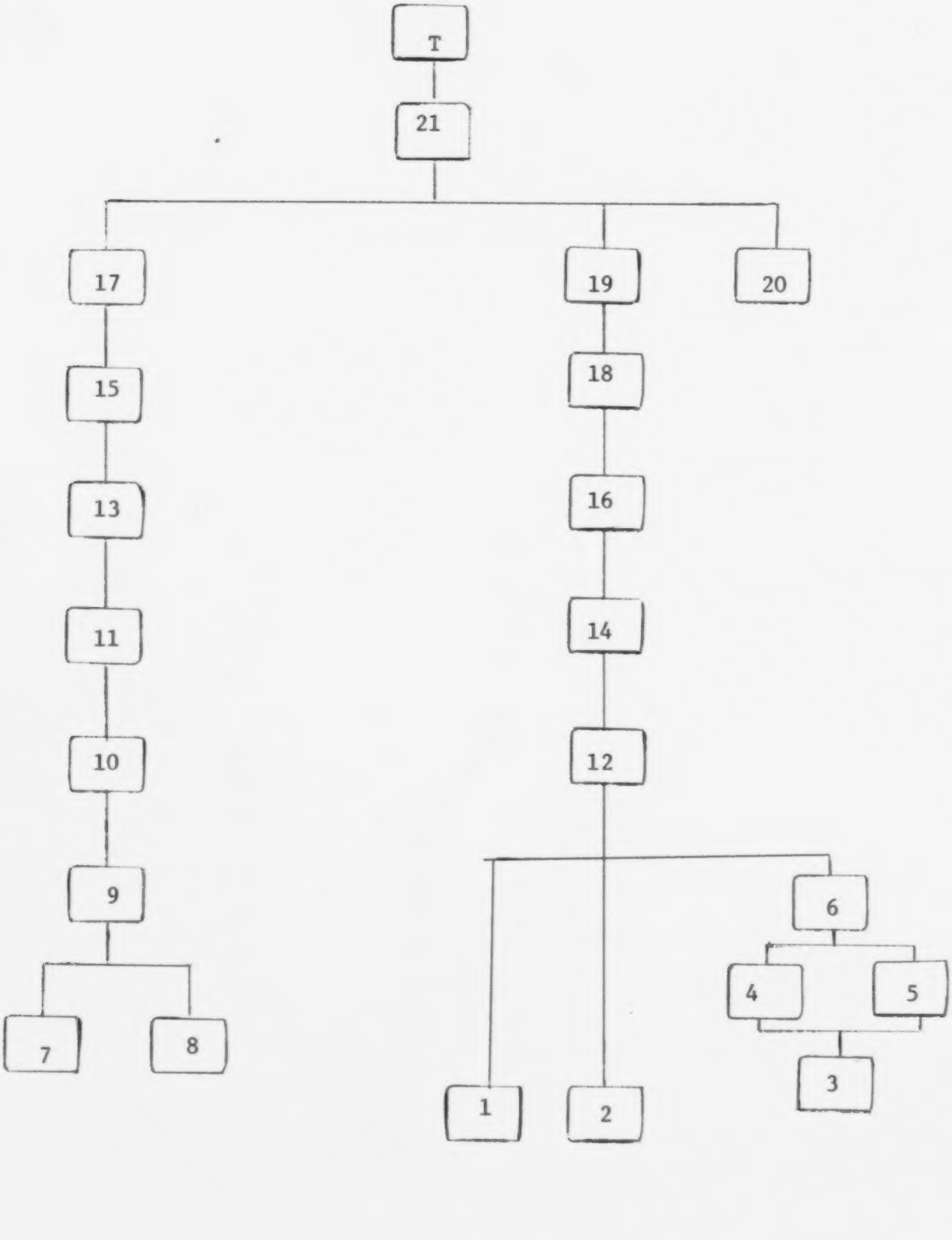
18. Given four wooden balls representing carbon atoms and instructions to saturate them with models of hydrogen atoms, the student constructs one of the isomers of butane with the molecular model kit.

19. Given the model constructed in objective 16 and another set of four wooden balls representing carbon atoms and instructions to construct a different model of butane, the student constructs the other isomer of butane with the molecular model kit.

20. The student names compounds having the same molecular formula but different arrangements of the atoms in the compound's isomers.

21. Given either a model of the butane molecule or illustrations of the butane model, the student names it butane.

ALKANES I - HIERARCHY


T
21
17
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9
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3
1
2

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Pretest and Posttest

Performance is tested away from the computer terminal. The student is given the following instruction:

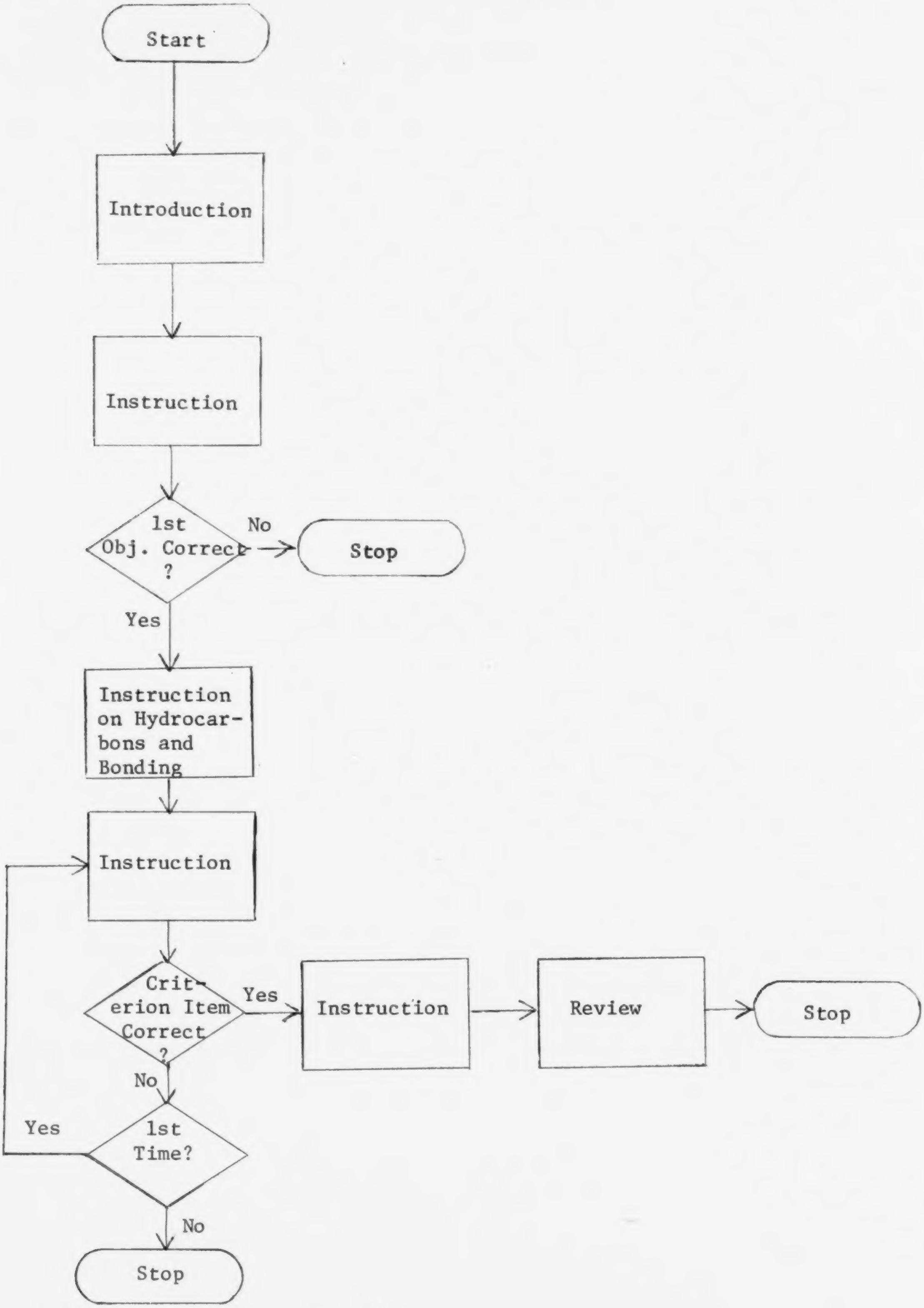
> "Using a molecular model kit, construct and name the first four molecular models of organic compounds in the alkane series of hydrocarbons, including the isomer of butane."

His performance is recorded for constructing and naming each of the five models.

Mode of Presentation

This program involves display of material on the cathode ray tube with the student responding by using the keyboard or light pen. Models constructed by the student are checked by the proctor; key words typed by the proctor according to the accuracy of the construction determine a student's instruction.

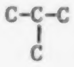
ALKANES I - INSTRUCTIONAL STRATEGY


Start
Introduction
Instruction
1st Obj. Correct ?
No
Stop
Yes
Instruction on Hydrocarbons and Bonding
Instruction
Criterion Item Correct ?
Yes
Instruction
Review
Stop
No
Yes
1st Time?
No
Stop

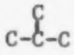
Sample Section of Program

In this program you will learn how to construct and name organic compounds in the alkane series of hydrocarbons.

Look at the molecular model kit on the table in front of you. Notice that there are several colors of wooden balls. Each of these different colors represents a particular atom.

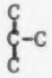


$\begin{array}{c}\mathrm{C-C-C}\\ |\\ \mathrm{C}\end{array}$

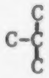


$\begin{array}{c}\mathrm{C}\\ |\\ \mathrm{C-C-C}\end{array}$

These arrangements may seem to be different but they are the same grouping of atoms.



$\begin{array}{l}\mathrm{C}\\ |\\ \mathrm{C-C}\\ |\\ \mathrm{C}\end{array}$



$\begin{array}{r}\mathrm{C}\\ |\\ \mathrm{C-C}\\ |\\ \mathrm{C}\end{array}$

d. ALKANES II

Assessment of Need

This modular instructional package is the second in a series on organic chemistry. The first MIP was designed to instruct students on the naming and building of models of organic compounds in the alkane series of hydrocarbons. This second MIP is being used to instruct students in determining and applying the formula for the alkane series of hydrocarbons.

Description of the Program

Alkanes II was designed and written by Richard K. King, a classroom teacher, and programmed in COURSEWRITER II by Susan Morgan. The tutorial package, utilizing the 1510 Instructional Display with keyboard and light pen, follows Alkanes I but requires a number of additional entering behaviors.

Terminal Objectives

The student applies the rule for finding the molecular formula of any compound in the alkane series of hydrocarbons.

Entering Behaviors

1. Given an algebraic expression in the form $2x + 2$ and a value for x, the student states the value of the expression.

2. The student distinguishes between a chemical formula and a mathematical formula.

3. Given a chemical formula of the form H_2SO_4, the student states the meaning of each subscript, including that of sulfur.

4. The student states the resulting formula when one alkane is added to another.

5. The student states the resulting formula when one alkane is removed from another alkane.

Enabling Objectives

1. Given the molecular formulas for the first four compounds in the alkane series of hydrocarbons, the student determines the difference in the carbon content between the first and second, the second and third, and the third and fourth compounds.

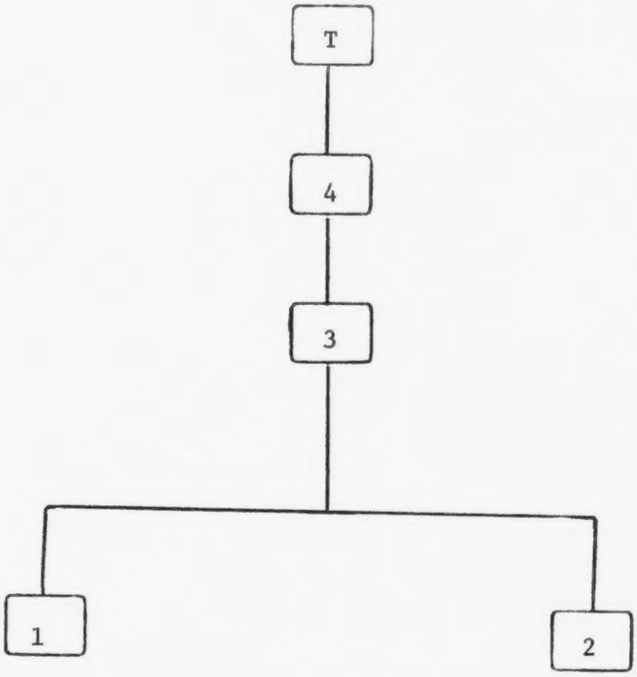
2. Given the molecular formulas for the first four compounds in the alkane series of hydrocarbons, the student determines the difference in the hydrogen content between the first and second, the second and third, and the third and fourth compounds.

3. Given the molecular formulas for the first four compounds in the alkane series of hydrocarbons, the student determines the relationship between the number of carbon atoms and the number of hydrogen atoms.

4. The student constructs the general formula for the alkane series of hydrocarbons.

5. The student applies the rule for finding the molecular formula of any compound in the alkane series of hydrocarbons.

ALKANES II - HIERARCHY



Pretest and Posttest

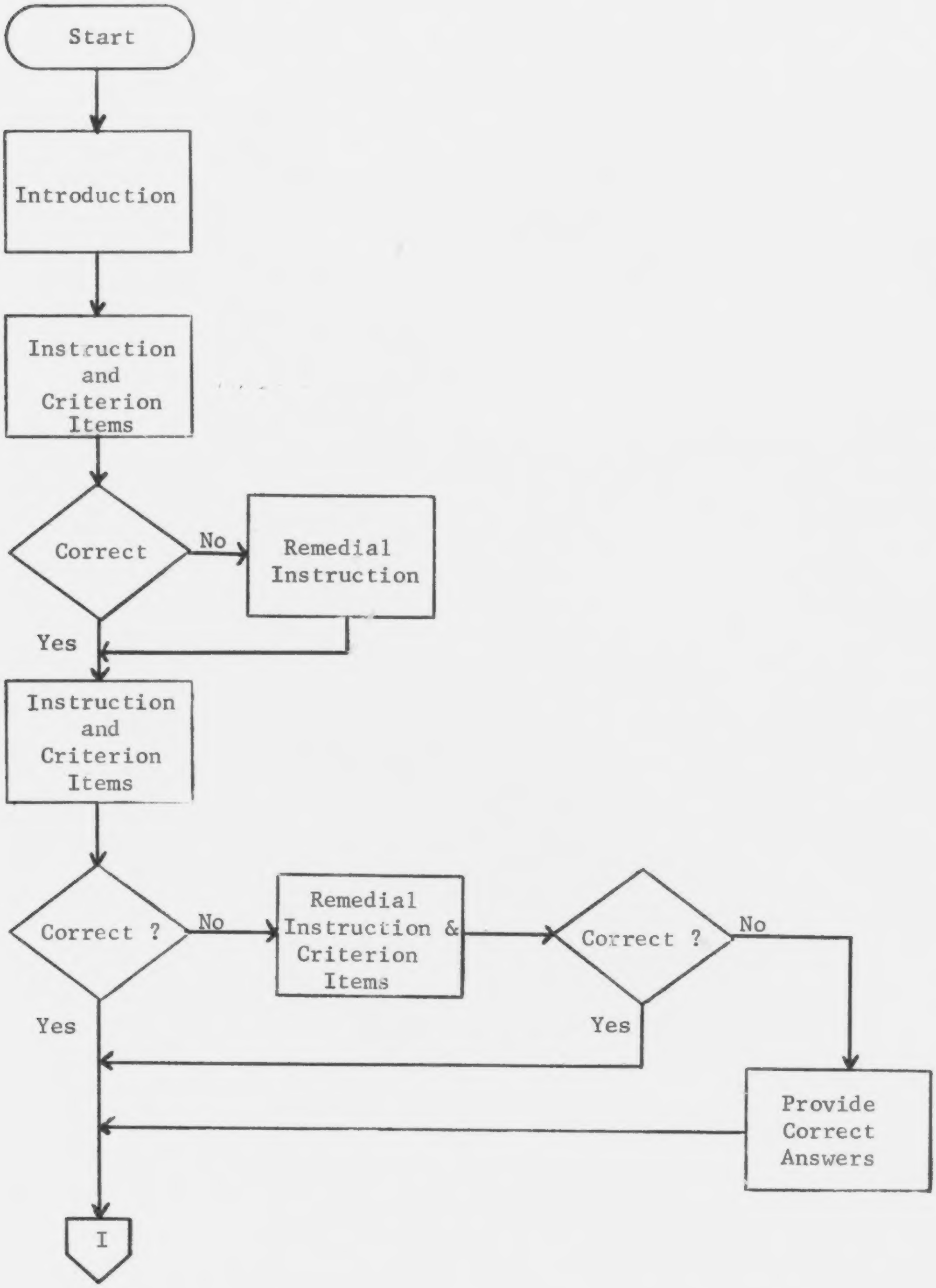
1. What is the algebraic formula for determining the molecular formulas for all compounds in the alkane series of hydrocarbons?

2. What would the molecular formula be for the seventh compound in the alkane series of hydrocarbons?

Mode of Presentation

The lesson segment is presented on the cathode ray tube of the instructional display, with keyboard and light pen used for responses. The entering behaviors test and pretest are given off-line.

ALKANE II - EXCERPT FROM INSTRUCTIONAL STRATEGY


Start
Introduction
Instruction and Criterion Items
Correct
No
Remedial Instruction
Yes
Instruction and Criterion Items
Correct ?
No
Remedial Instruction & Criterion Items
Correct ?
No
Yes
Yes
Provide Correct Answers
I

If C_4H_{10} is the fourth compound in the alkane series and the fifth compound in the series is made by adding a CH_2 group, what is the formula for the fifth compound?

☐ ________

K

5. What is the formula for the twenty-first compound in the alkane series of hydrocarbons?

☐ ________

K

The numbers you are working with are

1 and 4

2 and 6

What can you do to 1 to get 4 which will also work with the 2 to get 6?

☐ ________________________________

________________________________ K

Comments

The modular instructional package was used in the spring of 1971 with a limited number of students.

e. SOLUTIONS

Assessment of Need

The need for this program, authored by Keith C. Johnson and B. Jean Wastler, was determined by the junior high school science design team.

Description of the Program

In view of the fact that this package is still in the developmental stage, only terminal objectives, entering behaviors, and pretest and posttest have been included in this document.

Terminal Objectives

The student:

1. Defines a solution as a homogeneous mixture of two or more substances.
2. Identifies types of solutions based upon the three states of matter.
3. Names the principal parts of a solution as solvent and solute.
4. Defines concentrations of solutions based upon amounts of solute dissolved in solvent and defined as dilute or concentrated.
5. Defines concentrations of solutions as unsaturated, saturated, or supersaturated based upon amounts of solute dissolved in solvent.
6. Determines affect of temperature change of solvent upon solubility of a solid solute.
7. Determines affect of temperature change of solvent upon solubility of a gaseous solute.
8. Identifies at least six of the nine types of solutions and correctly identifies the principal examples of each used by man.

Entering Behaviors

1. Given three examples of common substances, the student classifies them as a gas, a liquid, or a solid.
2. Given an example of a gas, the student describes one of its properties as that a given amount will occupy the entire volume of its containers.
3. Given an example of a liquid, the student describes it as having a definite volume but taking the shape of its containers.
4. Given an example of a solid, the student describes it as having a definite volume and a definite shape.
5. Given an ice cube, the student describes how it can be changed to a liquid and then to a gas by adding heat energy.

Pretest and Posttest

1. When sand and water and sugar and water are combined and stirred, the result is called________.

   a. a compound
   b. a solution
   c. a mixture
   d. none of the above

2. A ____________ is formed when sand and water and sugar and water are combined and stirred.

3. Examine carefully the two mixtures given you by the proctor. Which mixture can be easily separated by pouring off the water? ____________.

   a. sugar and water
   b. sand and water
   c. copper sulfate and water

4. The____________ mixture can be easily separated by pouring off the water.

5. Examine carefully the five vessels given you by the proctor. Which of the vessels contain substances that are called mixtures? ____________.

6. The sand and water mixture seems to be ____________.

   a. uniformly mixed
   b. nonuniformly mixed
   c. not mixed at all
   d. none of the above

7. The sand and water mixture is said to be ____________ mixed.

8. The sugar and water mixture seems to be ____________.

   a. uniformly mixed
   b. nonuniformly mixed
   c. not mixed at all
   d. none of the above.

9. The sugar and water mixtures are said to be ____________ mixed.
   The sugar and water mixtures (is – is not) easily separated by pouring off the water.

10. A nonuniform mixture such as sand and water is defined as ____________.

    a. a homogenous mixture
    b. a heterogenous mixture
    c. a solution mixture
    d. none of the above

11. A sand and water nonuniform mixture is defined as a ____________ mixture.

12. A uniform mixture such as sugar and water is defined as ____________.

    a. a homogenous mixture
    b. a heterogeneous mixture
    c. a solution mixture
    d. none of the above

13. A sugar and water uniform mixture is defined as a ____________ mixture.

14. A uniform mixture such as sugar and water is defined as ____________.

    a. a solid
    b. a liquid
    c. a solution
    d. a gas

15. A ____________ is defined as a uniform mixture of two substances such as sugar and water.

f. A KEY TO IDENTIFICATION

Assessment of Need

The need for this program was determined by the design team as an essential tool for describing and classifying scientific items.

Description of the Program

The program is still in the developmental stage; therefore, only terminal objectives, enabling objectives, and the hierarchy are included in this document. This package was authored by Grace Tigani.

Terminal Objective

1. Given twelve objects with five or more common physical characteristics, the student groups all of them according to four common characteristics which he selects; and using those characteristics, he constructs a pattern or key which can be used to identify another object.

2. Given another object with those four common characteristics, he places the object in the correct group according to his key.

3. Given a position of his key, he describes any object that would fit into that position.

4. Given an object which does not fit into any particular position in the key, he orders it into its proper location by developing an additional group.

Enabling Objectives

1. Given twelve objects with five or more common physical characteristics, the student lists at least four of the common physical characteristics of the objects.

2. Given twelve objects, at least six of which have a common physical characteristic, the student identifies the common characteristic as a basis for grouping.

3. Given a group of identical objects to subdivide, the student identifies the objects as a group which has no basis for further subdivision.

4. Given twelve objects, the student sorts them into two groups with members of each group having at least one characteristic in common.

5. Using the two groups of objects which he previously developed, the student selects one of these groups and sorts the members according to another common characteristic so that members of each group have at least two characteristics in common: the previous one and the newly selected one.

6. Using the groups which he developed in Objective 5, the student selects one of the groups and sorts the members, using another common characteristic; members of each group will now have at least three common charactersitics: two previously selected ones and the newly chosen one.

7. Using the groups which he developed in Objective 6, the student selects one of these groups and sorts the members, using another common characteristic; members of each group will now have at least four common characteristics, three previously selected ones and the newly selected one.

8. Given the characteristics for each of the four groups, the student writes a statement describing each of these characteristics.

9. Having selected the four common characteristics of the given objects, the student identifies the most common characteristic and places it in the primary position in his organization of the key.

10. From the group of given characteristics, the student selects the next most common characteristic and places it in position directly below the first characteristic.

11. From the group of given characteristics, the student selects the third most common characteristic and places it in position below the ones previously selected.

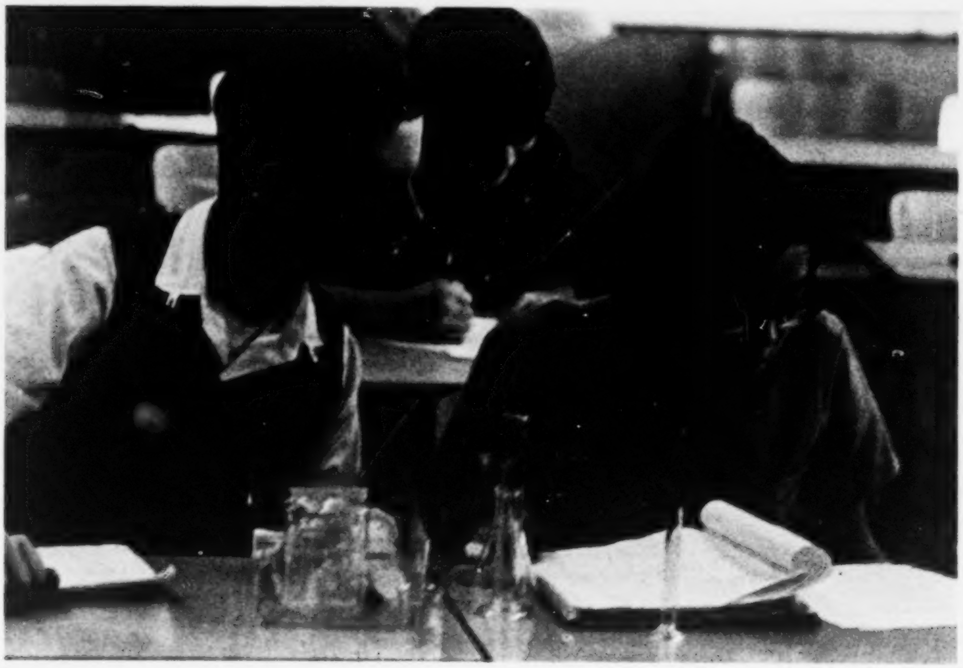
12. From the group of given characteristics, the student places the last characteristic in position below the previous ones.

13. Having arranged the characteristics in order from most common to least common, the student develops a hierarchy of this arrangement.

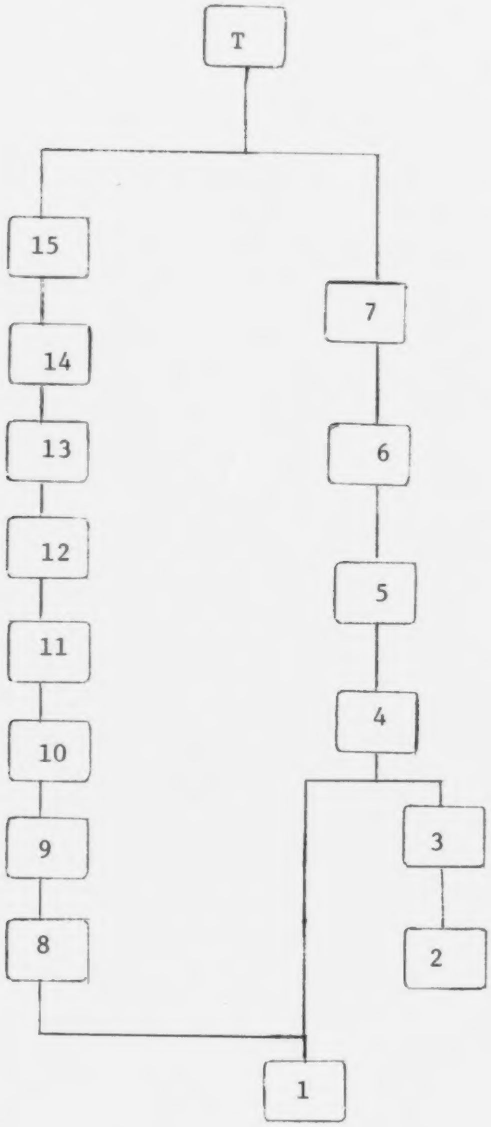
14. The student adds to the hierarchy illustrations that more groups can be developed using variations of one characteristic.

    Example: If the characteristic is color, separate groups are developed for each color: yellow, blue, green, etc.

15. Using the hierarchy, the student constructs a chart of the arrangement.



A KEY TO IDENTIFICATION - HIERARCHY


T
15
14
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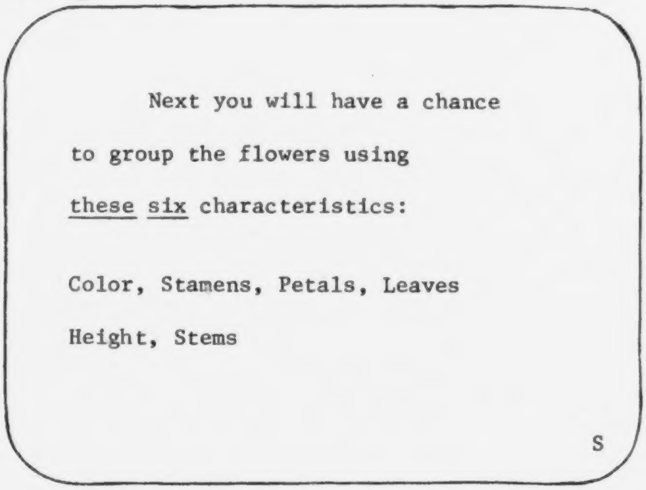
6
5
4
3
2
1

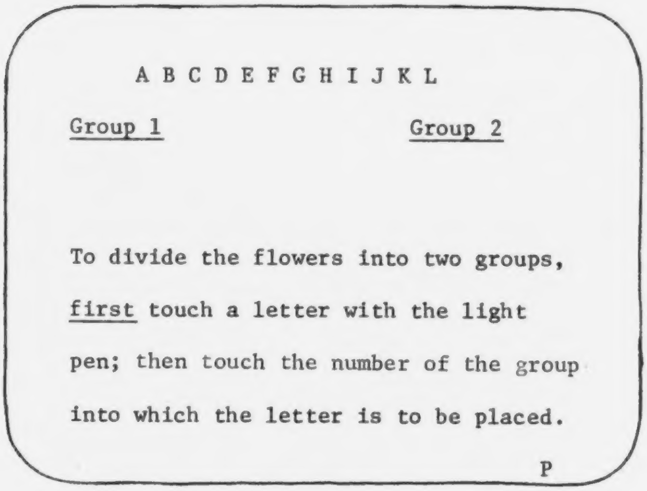
Sample Section of Program



Next you will have a chance to group the flowers using these six characteristics:

Color, Stamens, Petals, Leaves
Height, Stems

S

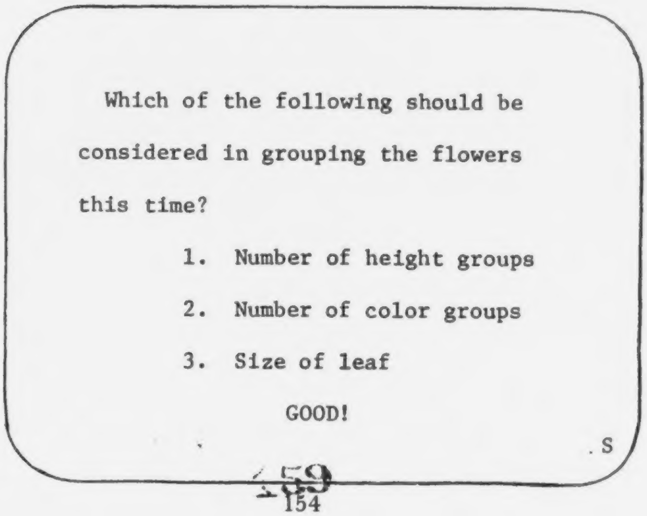


A B C D E F G H I J K L

Group 1 Group 2

To divide the flowers into two groups, first touch a letter with the light pen; then touch the number of the group into which the letter is to be placed.

P



Which of the following should be considered in grouping the flowers this time?

1. Number of height groups
2. Number of color groups
3. Size of leaf

GOOD!

S

g. GETTING TO KNOW THE COMPUTER

Assessment of Need

This package follows and supplements the modular instructional package Entry. After the student is able to proceed through a lesson segment and respond, using the light pen and keyboard, there are still many special operations he may want to perform during his on-line instruction. If the student is going to make decisions about his knowledge, based upon his particular learning style, he must be able to exercise some control over the display images and materials. Operations which may aid his learning, enable him to answer in a usual form, or assist in program evaluation have been included in this package.

Description of the Program

Junior high school students, using the 1510 Instructional Display Unit, are able to guide and control some of their own learning experiences by employing the computer capabilities available in this COURSEWRITER II program. The program, authored by B. Jean Wastler, includes practice in using space bar, light pen, and the keyboard.

Terminal Objective

The student, using the 1510 Instructional Display, performs the following functions:

- Backup
- Review and return
- Comment
- Desk calculator and return
- Index and return
- Entire line erasure
- Glossary and return
- Superscript
- Subscript

Entering Behaviors

The student uses the space bar of the keyboard to change a display (forward) when an S appears in the lower right corner of the display. When a P appears in the lower right corner of the screen, the student presses the light pen to an indicated lighted area of the screen. When a K appears in the lower right corner of the CRT, the student presses one or more keys on the keyboard and then enters his response by pressing the altnerate code key and space bar at the same time.

Enabling Objectives

The student:

1. States the condition which must exist before a special function such as backup, review, or comment can be used.

2. Identifies *b* as the key to be used for the backup.

3. Presses the *b* key when an S appears in the lower right corner to backup in a program.

4. Identifies *c* as the key to be used for the comment.

5. Enters a comment when an S appears in the lower right corner by pressing the *c* key, typing a comment, and entering the comment by pressing the alternate code key and the space bar. (A comment of 35 characters is entered automatically.)

6. Identifies *g* as the key to be used for the glossary.

7. Identifies *e* as the key to be used to exit from special function transfer segments such as glossary, review, and calculator and to enter back into the original program.

8. Uses the glossary function and returns to his program.

9. Identifies *i* as the key to be used for the index.

10. Uses the index function and returns to his program.

11. Identifies *r* as the key to be used for the review.

12. Uses the review function and returns to his program.

13. Identifies +, –, x or ÷ as the keys to be used for the calculator function.

14. Demonstrates how to add, subtract, multiply, and divide within the calculator function.

15. Uses the calculator function and returns to the program.

16. Identifies the alternate code and minus keys as those used to "erase" an entire line.

17. Erases an entire line of a keyboard response by using the alternate code and minus keys.

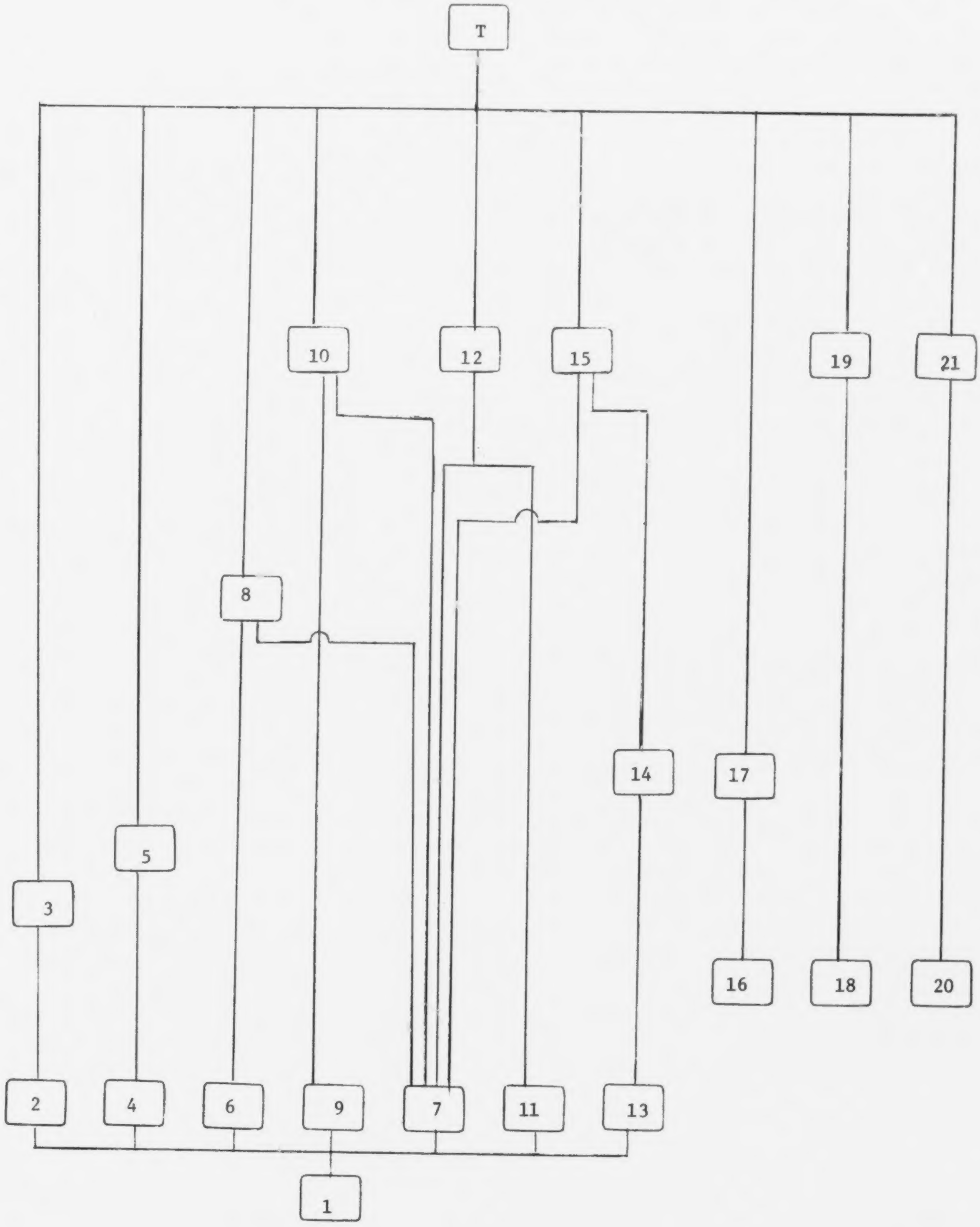
18. Identifies the alternate code and a number key as those used to place a number in a subscript position.

19. Presses the alternate code key and a number key to insert a numbered subscript such as the *2* in H_20 in a keyboard response.

20. Identifies the alternate code key and a letter key as those used to place a number in a superscript position.

21. Presses the alternate code key and the letter key to the right beneath the number he wants to insert a numbered superscript such as the *2* in 10^2 in a keyboard response.

GETTING TO KNOW THE COMPUTER - HIERARCHY


T
10
12
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21
8
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17
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3
16
18
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2
4
6
9
7
11
13
1

Pretest and Posttest

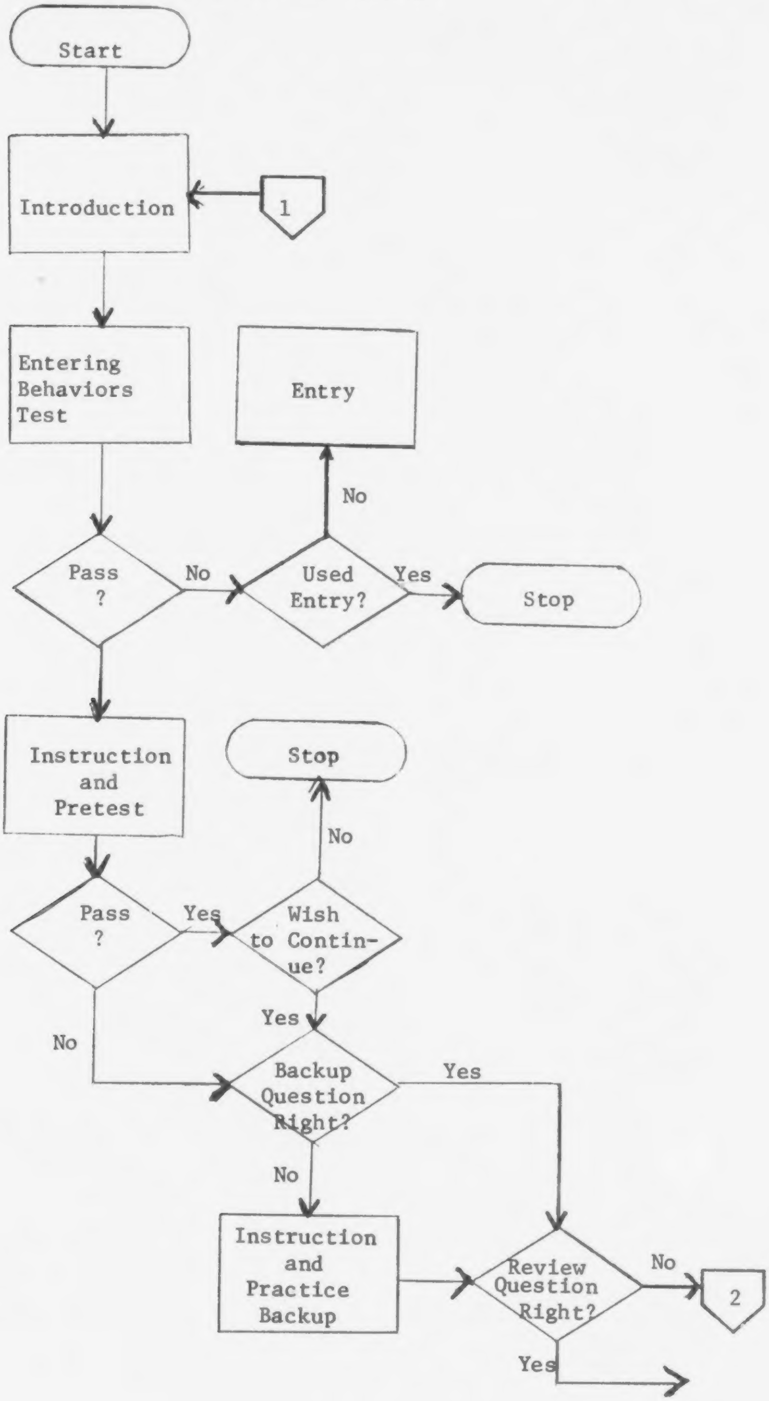
1. What conditions must exist before a special function such as backup, review, or comment can be used?
2. Back up to the directions.
3. Enter a comment about the student station; then continue in the program.
4. Call the first frame of the glossary on your screen; then continue in the program.
5. View the index frame once, then continue in the program.
6. Use the review function once, view just the title frame, and then continue from here.
7. Use the calculator function to add three numbers; then continue in the program.
8. Type a line of letters and then wait for an observer.
9. Show the observer how to erase an entire line of material.
10. Type 10^2 on this line _____________.
11. Type H_20 on this line _____________.

Mode of Presentation

The 1510 Instructional Display with light pen is needed for this program. Several demonstrations require the presence of an observer. A form to record *correct* or *incorrect* performance is available for the observer's use but notes would serve the purpose equally well.

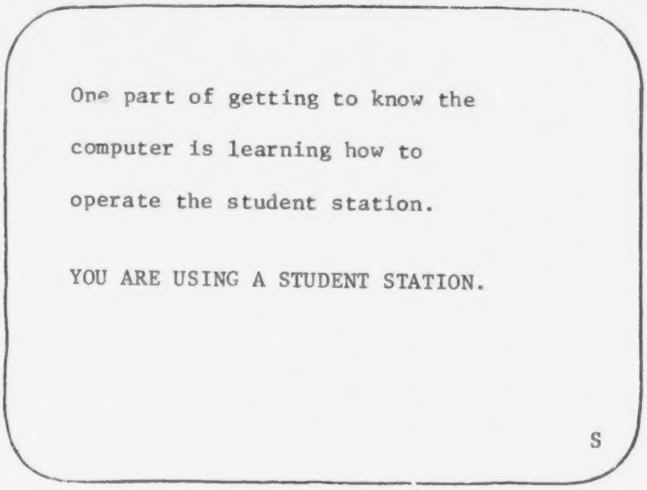
GETTING TO KNOW THE COMPUTER

EXCERPT FROM INSTRUCTIONAL STRATEGY


Start
Introduction
1
Entering Behaviors Test
Entry
No
Pass ?
No
Used Entry?
Yes
Stop
Instruction and Pretest
Stop
No
Pass ?
Yes
Wish to Continue?
Yes
No
Backup Question Right?
Yes
No
Instruction and Practice Backup
Review Question Right?
No
2
Yes

164

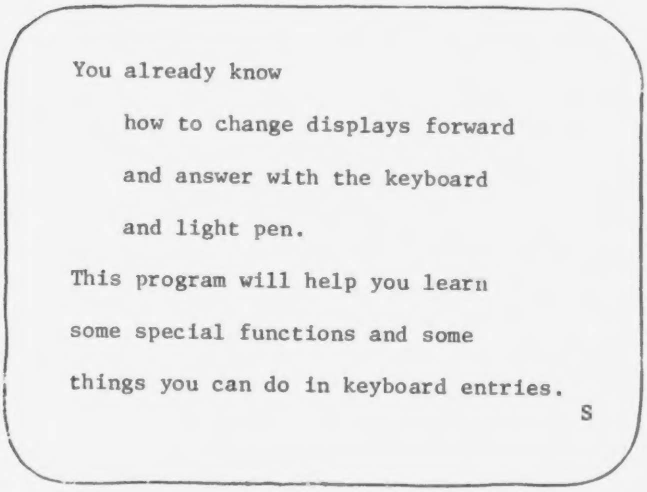
Sample Section from the Program



One part of getting to know the
computer is learning how to
operate the student station.

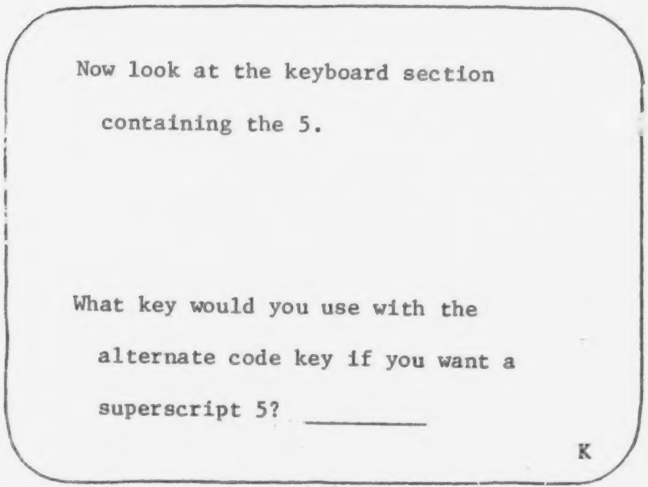
YOU ARE USING A STUDENT STATION.

S



You already know
how to change displays forward
and answer with the keyboard
and light pen.
This program will help you learn
some special functions and some
things you can do in keyboard entries.

S



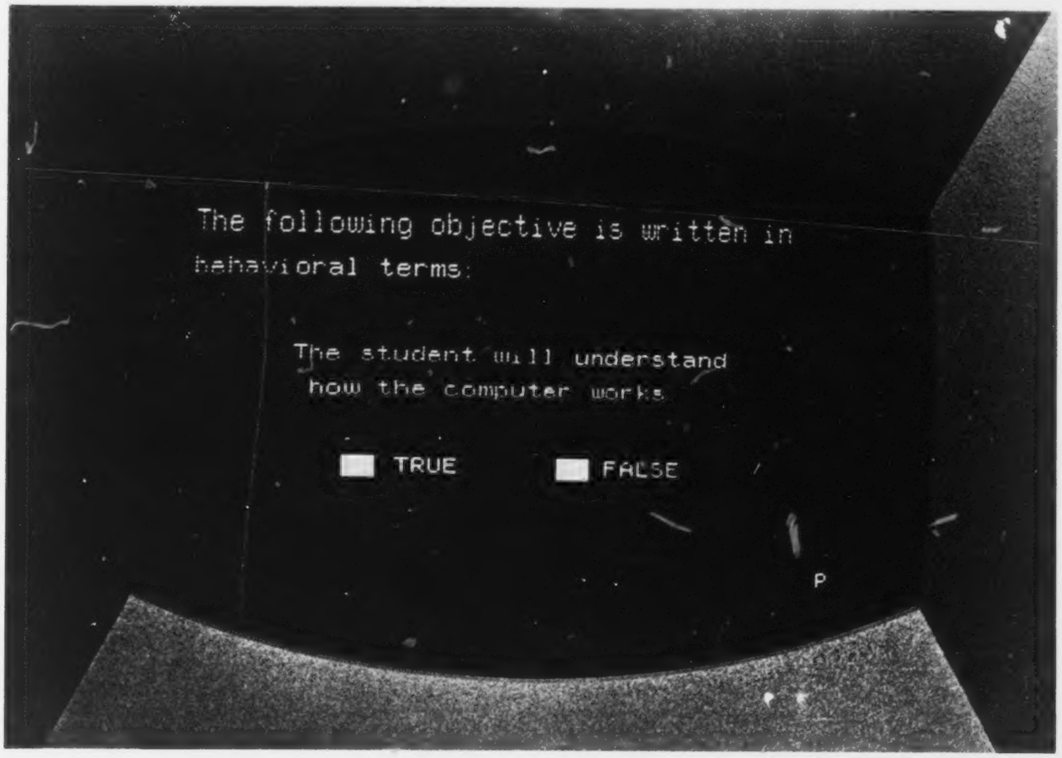
Now look at the keyboard section
containing the 5.

What key would you use with the
alternate code key if you want a
superscript 5? ________

K

Comments

The program was planned as a complete student-computer terminal packet. No additional instructional aids are used with the tutorial material. An orientation session between the author and the proctor to help with anticipated student problems or questions is desirable but not essential.



The following objective is written in behavioral terms:

The student will understand how the computer works.

☐ TRUE ☐ FALSE

3. SENIOR HIGH MATHEMATICS

by
Catherine E. Morgan
and
Thomas E. Robinson

The Design Team

a. Ratio and Proportion

b. Dimensional Analysis

c. Slope of the Line

d. Radical Review

e. Factoring

f. Introduction to Vectors

g. Geometry Testing

h. Problem Solving

i. Trigonometric Solutions of Right Triangles

j. Perimeter-Area Investigation

k. Volume-Area Investigation

l. Car Ownership

m. APL Remote Computing and Program Writing

THE DESIGN TEAM

Mrs. Catherine Morgan, teacher specialist in curriculum, and four design team members comprised the senior high mathematics materials development group through Phases I and II. Two mathematics teachers also participated in each of the first two supporting teacher training sessions. When one of the first design team members moved away, a summer workshop member was designated to join the team. Later, a second supporting teacher left the project when he was promoted to an administrative position. His replacement was selected from a geometry workshop group. In January, 1971, Mrs. Morgan was named acting director of the project, and Thomas E. Robinson, a mathematics design team member, was appointed to the position of teacher specialist. Subsequently, a replacement from the geometry workshop was sought for the design team role.

Mrs. Morgan joined the CAI Project in August, 1968. Her previous experience included ten years of teaching mathematics at Kensington Junior High School where she also served as the department resource teacher for three years. She earned both B.A. and M.Ed. degrees at the University of Maryland, concentrating in mathematics education and psychology. In addition, she had participated in a workshop on gifted children and taken an IBM data processing course. During Phase II of the project, she devoted 80 per cent of her time to designing, developing, and implementing eleven modular instructional packages, eight of which are described in this document. Her concerns for the individual and his needs have reflected in her project work.

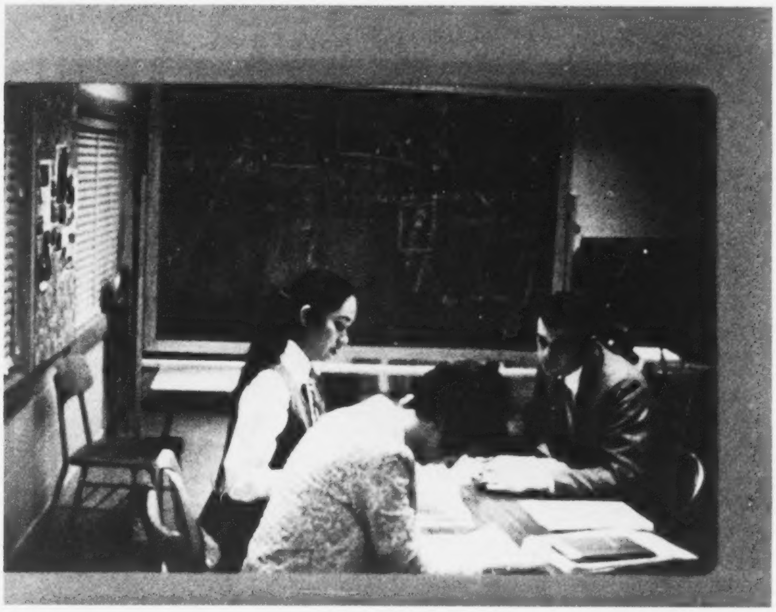
Joan Piersol, mathematics resource teacher at Gaithersburg High School, and Merrill E. Fisher, mathematics teacher at Bethesda-Chevy Chase High School, were selected by the design team leader to participate in the initial teacher training workshop. Miss Piersol and Mr. Fisher subsequently co-authored the lesson segment, Slope of the Line. Mr. Fisher left the authoring group in July, 1969, when he was promoted to administrative assistant to the assistant superintendent for administration.

Thomas Robinson, a teacher in the mathematics department at Albert Einstein High School, and Eleanor Lautenschlager, Kensington Junior High School mathematics teacher, were designated by Mrs. Morgan for the second supporting teacher training workshop. Both completed the training sessions and remained with the design team to author modular instructional packages. At the time of his selection for the training sessions, Mr. Robinson, whose undergraduate major at Wake Forest University was mathematics, had taught Algebra II for six months in the high school housing the CAI Project. Included in the credits for his B.S. were computer programming courses in FORTRAN, machine languages, SPS and PL/1. Since joining the project, he has been doing graduate work in secondary school administration and supervision at George Washington University. He has authored and co-authored several segments, including Radical Review, Trigonometric Solutions of Right Triangles, and Algebra II Examination and Evaluation.

A graduate of William Jewell College, Liberty, Missouri, Eleanor Lautenschlager had taught eleven and a half years before joining the CAI staff as a part-time participant. Her teaching experiences included seventh, eighth, and ninth grade mathematics, geometry, Algebra I, and seventh and eighth grade science. She is continuing her studies with work toward a Master's degree in secondary education at George Washington University. Recent courses have included empirical research, abstract algebra, and matrix theory. Authoring of materials by Mrs. Lautenschlager has been on a continuing basis since completion of the CAI training program.

Anne Roger, a participant in the geometry curriculum workshop, was selected by the design team leader to fill a vacancy in the fall of 1969. She holds a B.S. degree in mathematics education from the University of Illinois. Her two years of teaching experience had been at the junior high level with seventh and eighth grade students. She did not participate in a training group but did have six hours of graduate credit from previous course work in behavioral objectives. Her contribution to the design team has been work on the computer-assisted test items in geometry.

A participant from the CAI summer workshops, Nicholas Guidara, was designated for design team membership by project staff members. (See Staff Development Section for a description of the summer 1969-1970 workshop.) At the time the list of participants in the supporting teacher program had to be finalized for the 1969-1970 academic year, a vacancy existed in the mathematics team. Mr. Guidara, a mathematics teacher at Bethesda-Chevy Chase High School, had begun a lesson segment on significant digits during the workshop. He continued developing the segment and assisted in the adaptation of the geometry testing items for computer use.



a. RATIO AND PROPORTION

Assessment of Need

Ratio and proportion is an important mathematical concept, useful in many areas. While excellent programs of an elementary nature are available, their objective is the solution of simple problems in direct variation. Assumption is made that students can generalize to other types of variation with a minimum of instruction. This subject area was identified for development by the author, Catherine Morgan, after surveying areas of mathematics difficulties expressed by science students at Albert Einstein and Walter Johnson High Schools.

Description of the Program

This program is divided into two distinct areas: (1) a tutorial dialogue to teach the identification of each type of variation, and (2) a student-controlled inquiry section in writing proportions for each type of variation.

Catherine Morgan, teacher specialist in curriculum, designed and authored the segment. Chris Hoffman, Anne Metzger, and Priscilla Smith coded the COURSEWRITER II program. This program has as its target population senior high students in Algebra II, Advanced Algebra and Trigonometry, and geometry courses. The student station for this program consists of the 1510 Instructional Display with light pen.

Terminal Objective

Given four problems, the student sets up and solves proportions involving direct, joint, inverse, and combined variations.

Entering Behaviors

Given four proportions of the form: $\frac{a}{b} = \frac{c}{d}$ where any three represent rational numbers and the fourth is a rational unknown number in the form x, x^2, or x^3 (if x^3, then x must be rational), the student solves them. (See enabling objectives A1 – A10.)

Enabling Objectives

A1 The student identifies a fraction (common, decimal, or per cent) as a ratio.

A2 The student identifies a mathematical sentence with two equal ratios as a proportion.

A3 The student transforms proportions by multiplying each side of the equation by a common multiple of the denominators.

A4 The student transforms a proportion by getting a common denominator for each side of the proportion.

A5 The student uses the principle of the product of the means equals the product of the extremes.

A6 The student transforms proportions from fractional forms to one of the following:

1. $ax = b$
2. $ax^2 = b$
3. $ax^3 = b$

A7 The student solves equations of forms: $ax = b$

A8 The student solves equations of form: $ax^2 = b$

A9 The student solves equations of form: $ax^3 = b$

A10 The student solves a proportion of form: $\frac{a}{b} = \frac{c}{d}$ (a, b, c, d – one literal and three rational; literal will represent a real number if degree is 1 or 2, a rational number if degree is 3).

A1 – A10 are enabling objectives for ratio and proportion but are entering behaviors for this computer program.

B1 Given statements, the student identifies whether or not the situation illustrates variation.

B2 Given statements, the student identifies whether or not the situation illustrates direct variation.

B3 Given statements, the student identifies whether or not the situation illustrates joint variation.

B4 Given statements, the student identifies whether or not the situation illustrates inverse variation.

B5 Given statements, the student identifies whether or not the situation illustrates combined variation.

B6 Given 10 problems, the student identifies the type of variation in at least 9.

B7 Given a situation, the student sets up problems involving direct variation.

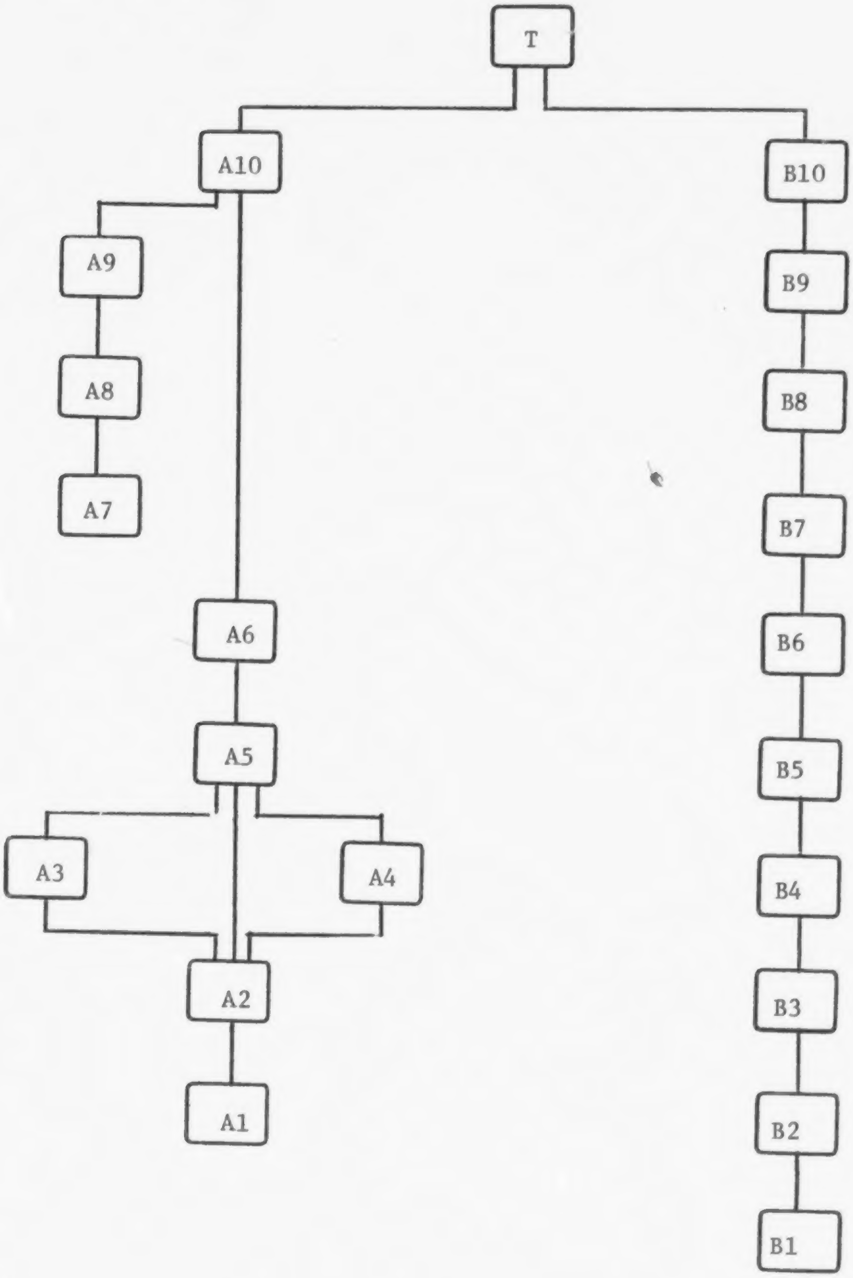
B8 Given a situation, the student sets up problems involving joint variation.

B9 Given a situation, the student sets up problems involving inverse variation.

B10 Given a situation, the student sets up problems involving combined variation.

B1 – B10 are enabling objectives for the computer program.

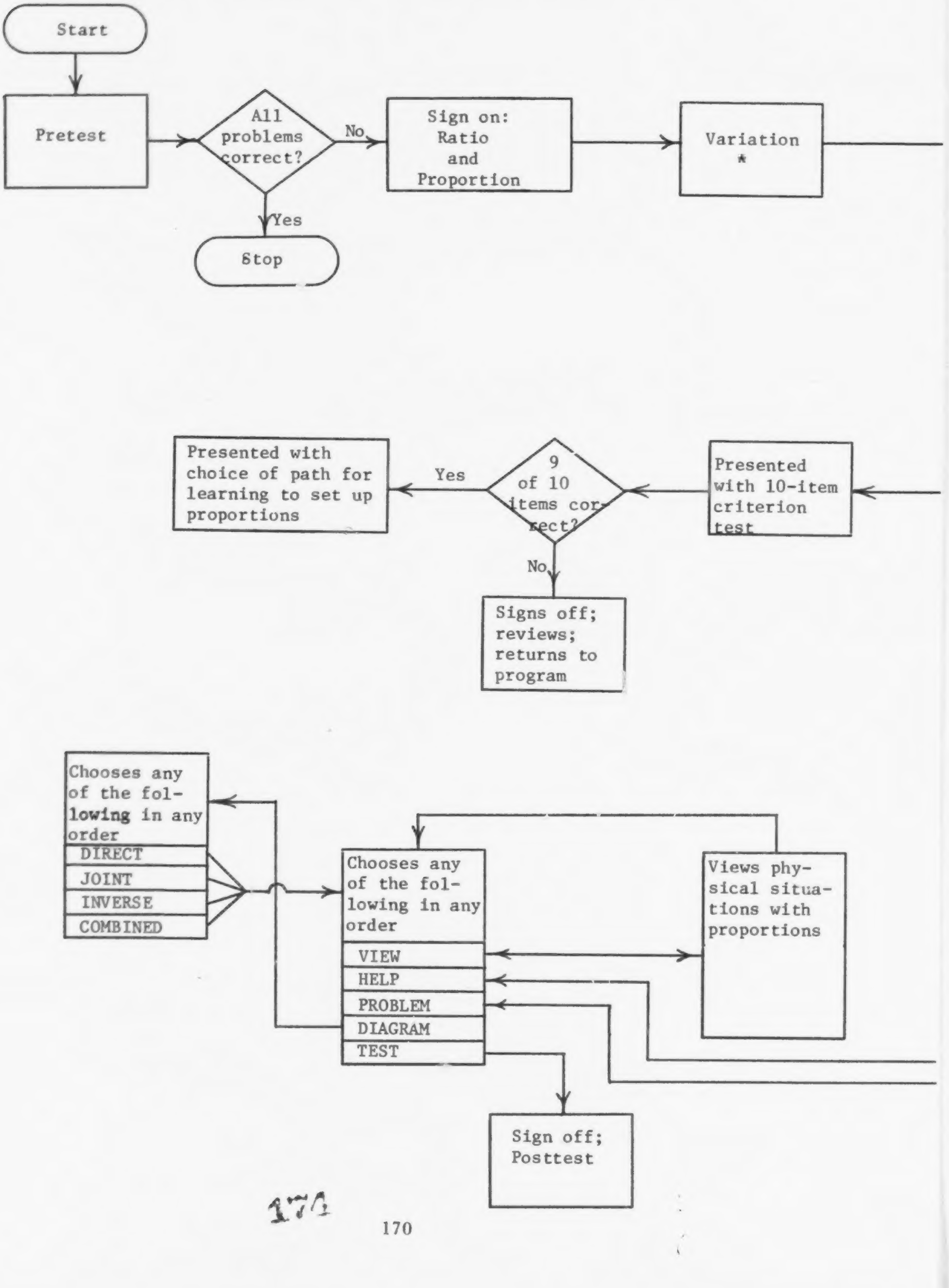
RATIO AND PROPORTION - HIERARCHY

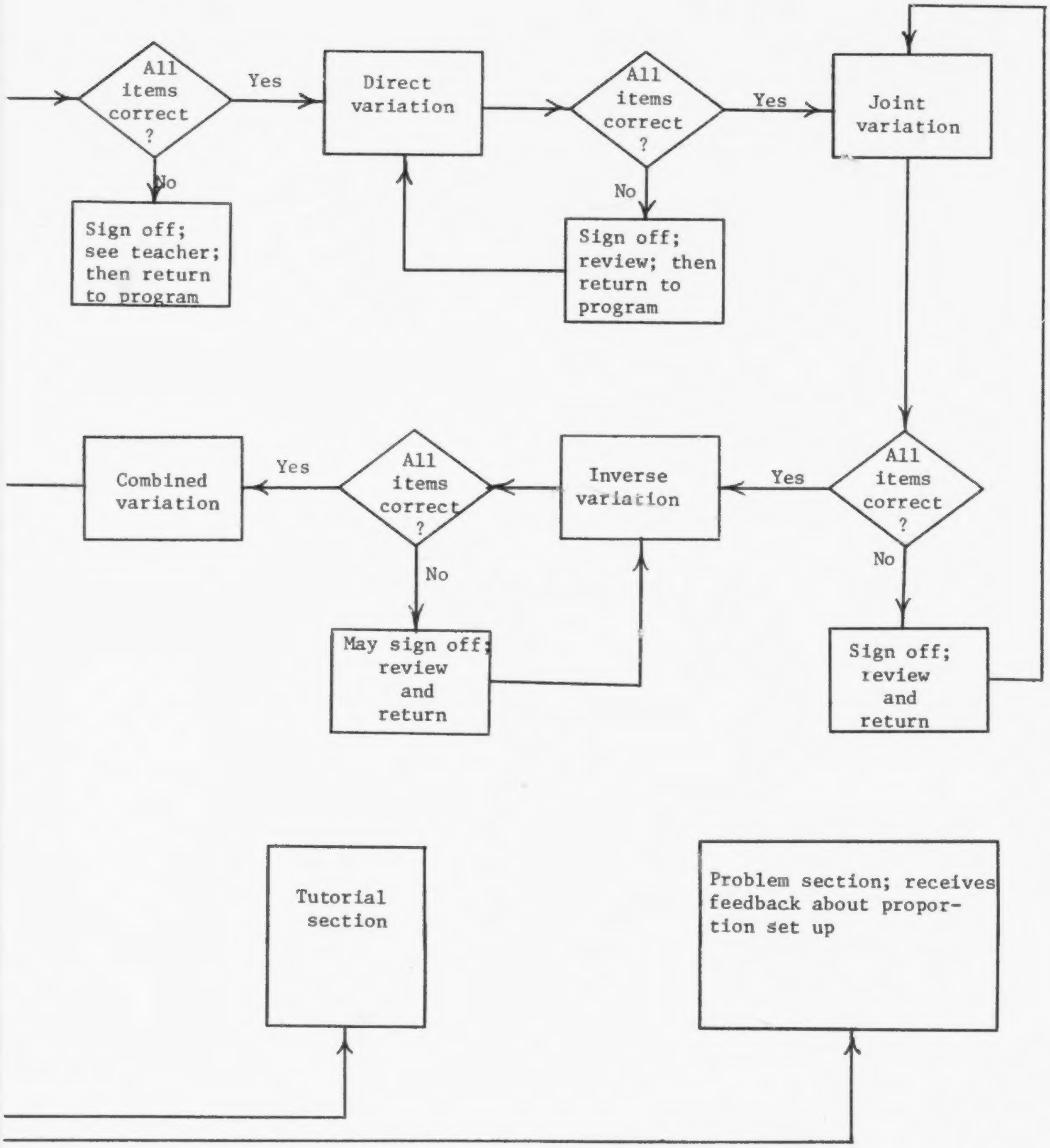

T
A10
B10
A9
B9
A8
B8
A7
B7
A6
B6
A5
B5
A3
A4
B4
A2
B3
A1
B2
B1

A1 - A10 are enabling objectives for ratio and proportion but are entering behaviors for this computer program.

B1 - B10 are enabling objectives for the computer program.

RATIO AND PROPORTION - INSTRUCTIONAL STRATEGY


Start
Pretest
All problems correct?
No
Yes
Stop
Sign on: Ratio and Proportion
Variation
*
Presented with 10-item criterion test
9 of 10 items correct?
Yes
No
Presented with choice of path for learning to set up proportions
Signs off; reviews; returns to program
Chooses any of the following in any order
DIRECT
JOINT
INVERSE
COMBINED
Chooses any of the following in any order
VIEW
HELP
PROBLEM
DIAGRAM
TEST
Views physical situations with proportions
Sign off; Posttest


All items correct ?
Yes
No
Sign off; see teacher; then return to program
Direct variation
All items correct ?
Yes
No
Sign off; review; then return to program
Joint variation
All items correct ?
Yes
No
Sign off; review and return
Inverse variation
All items correct ?
Yes
No
May sign off; review and return
Combined variation
Tutorial section
Problem section; receives feedback about proportion set up

* Instruction on identification of situations illustrating the specified type of variation.

Pretest

1. If a circle with a radius of six units has an arc of 3.6 units, what is the arc with the same central angle of a circle with a radius of ten units?

2. If two boys can mow a large lawn in seven hours, how long will it take three boys (to the nearest tenth of an hour, assuming they work at the same rate)?

3. If a cylinder which has a base area of four square units and a height of five units holds 62.8 gallons of liquid, how much liquid will another cylinder with a base area of nine square units and a height of six units hold?

4. The load on a horizontal beam supported at its ends varies directly as the square of the beam's depth and inversely as its length between supports. A beam ten feet long and six inches deep bears 1350 pounds. What load can one beam 16 feet long and eight inches deep bear?

Posttest

1. The amount of real estate taxes varies as the assessed value of a house. What will the taxes be on a $35,000 house if the taxes are $495 on a $22,500 house?

2. The volume of a particular container varies as its height and the area of its base. How much water can be held in a container with a base area of four square feet and a height of three feet, if a similar container with a base area of five square feet and a height of two feet holds 25 gallons of water?

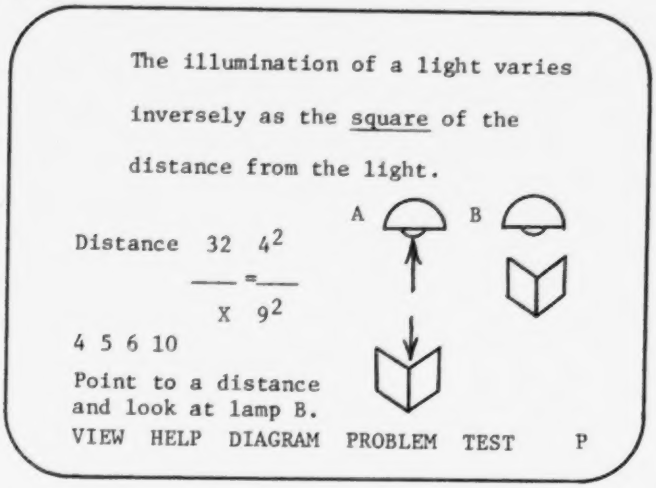
3. If a machine can make 150 articles in seven hours, how long will it take five machines to make the same number of articles?

4. Centripetal force varies directly as the square of the speed of the moving object and inversely as the radius of its circular path. A body moving in a circular path with a radius of five feet at 25 feet per second has a centripetal force of 1200 pounds. What is the force for the same body moving a circular path of radius three feet at 30 feet per second?

Mode of Presentation

Following instruction related to the type of variation illustrated in the physical situations described, the student has the opportunity to make decisions about the content, order, and duration of instruction and practice setting up proportions for direct, joint, inverse, and combined variation.

Sample Section of Program



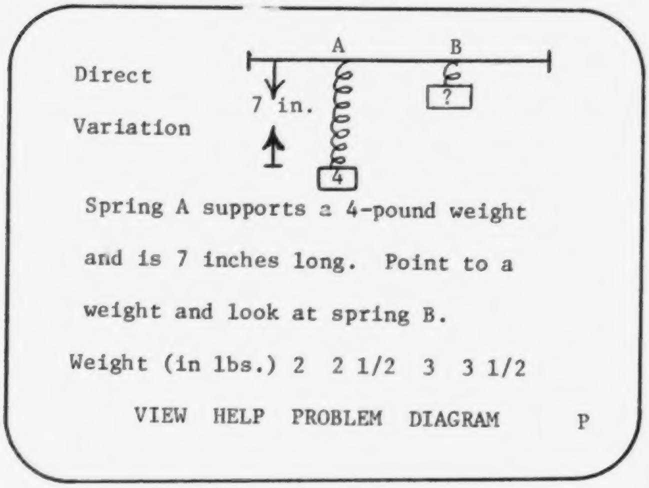
The illumination of a light varies inversely as the square of the distance from the light.

Distance $\frac{32}{X} = \frac{4^2}{9^2}$

4 5 6 10

Point to a distance and look at lamp B.

A
B
VIEW HELP DIAGRAM PROBLEM TEST P

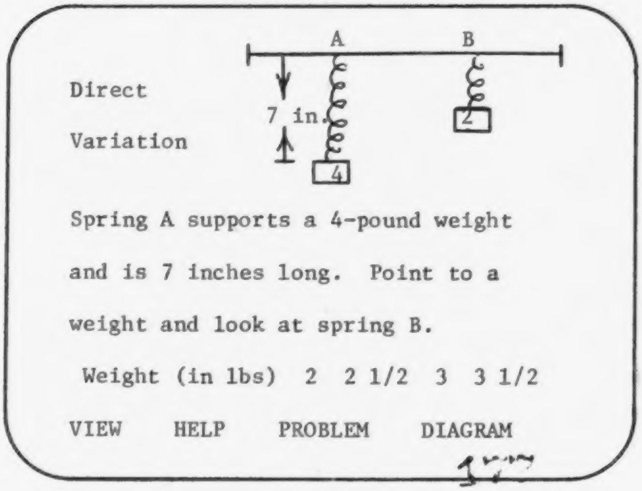


Direct Variation

Spring A supports a 4-pound weight and is 7 inches long. Point to a weight and look at spring B.

Weight (in lbs.) 2 2 1/2 3 3 1/2

A
B
7 in.
?
4
VIEW HELP PROBLEM DIAGRAM P



Direct Variation

Spring A supports a 4-pound weight and is 7 inches long. Point to a weight and look at spring B.

Weight (in lbs) 2 2 1/2 3 3 1/2

A
B
7 in.
2
4
VIEW HELP PROBLEM DIAGRAM

For each of the problems which follow, type "yes" if it is an illustration of inverse variation and "no" if it is not.

Look at Image 11

1. The distance from the center of a seesaw depends on the weight of the children. Does the distance increase as the weight decreases?

☐

K

2. The number of men required to dig a trench depends on the size of the trench if the time is unchanged.

Is this an example of inverse variation?

☐

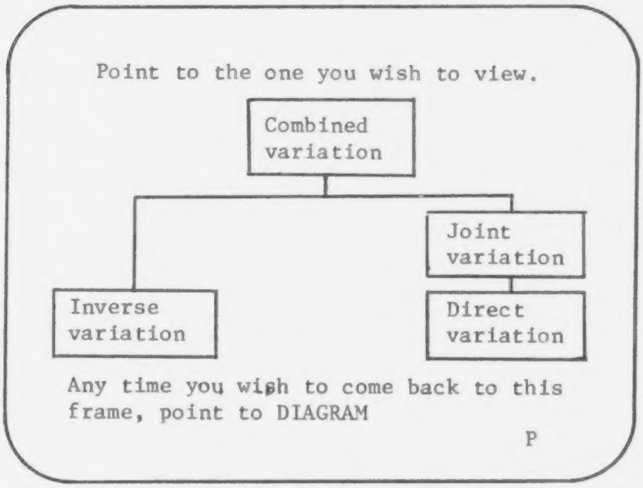
K

3. The amount of interest on a loan of $500 depends on the rate of interest.

Is this an example of inverse variation?

☐

K

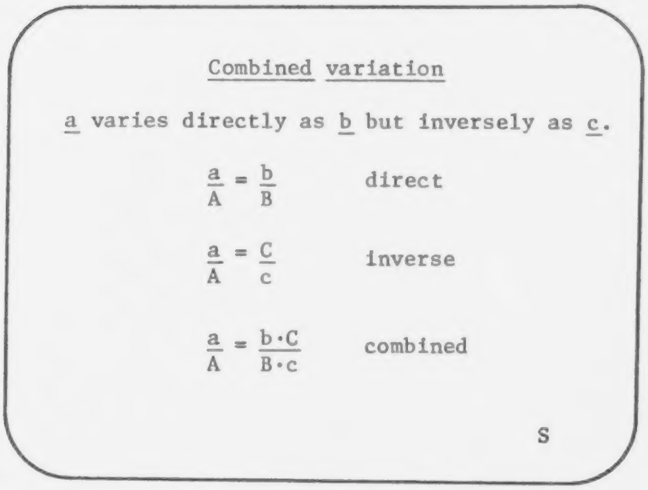


Point to the one you wish to view.

Combined variation
Joint variation
Inverse variation
Direct variation

Any time you wish to come back to this frame, point to DIAGRAM

P



Combined variation

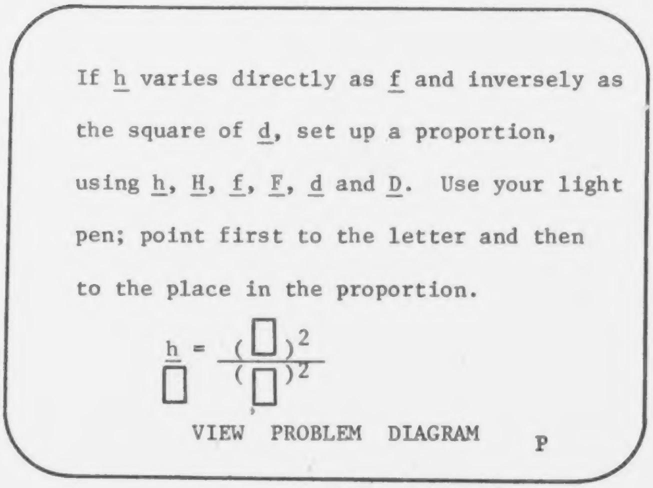
a varies directly as b but inversely as c.

$\frac{a}{A} = \frac{b}{B}$ direct

$\frac{a}{A} = \frac{C}{c}$ inverse

$\frac{a}{A} = \frac{b \cdot C}{B \cdot c}$ combined

S



If h varies directly as f and inversely as the square of d, set up a proportion, using h, H, f, F, d and D. Use your light pen; point first to the letter and then to the place in the proportion.

$$\frac{h}{\square} = \frac{(\square)^2}{(\square)^2}$$

VIEW PROBLEM DIAGRAM

P

Comments

This segment was first used in the summer of 1969, as a part of the Tie Your Math To Your Science course for chemistry and physics students. See the Validation and Evaluation Data section for information on its validation for that group and for Advanced Algebra and Trigonometry students. The latter validation occurred during the first semester of 1969-1970. This was the mathematics teacher specialist's first CAI development.

b. DIMENSIONAL ANALYSIS

Assessment of Need

The need for this program was determined by responses gathered from approximately 850 questionnaires distributed to students in physics and chemistry classes at Einstein and Walter Johnson High Schools. These science students were asked to identify areas of mathematics in which they needed help in order to perform more adequately in their science courses. Dimensional analysis was one such area.

Description of the Program

The Dimensional Analysis program contains a diagnostic test providing twenty-three different paths for testing and subsequent possible instruction. Prior to instruction, the student may be presented with as few as four questions and as many as ten questions in the diagnostic test. A short optional section explaining how to change between the metric and English systems of measurement is available following successful completion of any path of instruction.

Dimensional analysis can be taught by a contrived interpretation of the mathematical property of the multiplicative identity. Although students should be instructed that only numbers can be used for calculations, the technique for finding equivalent measurement by the employment of the identity property can be most helpful.

Catherine Morgan, teacher specialist in curriculum, designed and authored the segment between October, 1968, and March, 1969. It was coded in COURSEWRITER II by Anne Metzger, a staff member at the CAI Project, and later validated in November, 1969.

Terminal Objectives

1. Given one, two, and three dimensional denominate numbers, the student writes equivalent measurements in the same system of measurement.

2. Given rates, the student writes equivalent rates in the same system of measurement.

Enabling Objectives

1. Given a list of units of measurements, the student identifies the one-dimensional units.

2. Given a table of linear measurement equivalents, the student writes the equivalencies designated.

3. Given a table of linear measurements and one value, the student writes an equivalent value from the table.

4. Given a list of numerals, the student identifies the name for the multiplicative identity.

5. Given a list of fractional numerals, the student identifies those which name the multiplicative identity.

6. The student constructs any fraction which names the multiplicative identity.

7. Given a list of fractions, the student constructs a new name for each, using the multiplicative identity.

8. Given a list of denominate numbers written in fractional numeral form, the student identifies those which name the multiplicative identity.

9. The student constructs fractional numeral names for the multiplicative identity, using denominate numbers.

10. Given one-dimensional units, the student constructs equivalent units using the multiplicative identity.

11. Given a list of units of measurement, the student identifies the square units as measures of area.

12. Given a list of mathematical sentences, the student identifies the sentence in which the square units equal the product of two linear measurements.

13. Given a list of units of measurements, the student identifies the cubic units as measures of volume.

14. Given a list of mathematical sentences, the student identifies the sentence in which the cubic units equal the product of three linear measurements or the product of one linear measurement and one square measurement.

15. Given a rate, the student identifies an equivalent as the quotient of two denominate numbers.

16. Given a rate, the student constructs the rate as the quotient of two denominate numbers.

17. Given a rate, the student constructs an equivalent by using the multiplicative identity.

18. Given a list of mathematical expressions, the student identifies those expressions which contain two fractional numerals consisting of denominate numbers and names the multiplicative identity.

19. The student constructs the multiplicative identity as the product of two fractional numerals consisting of denominate numbers.

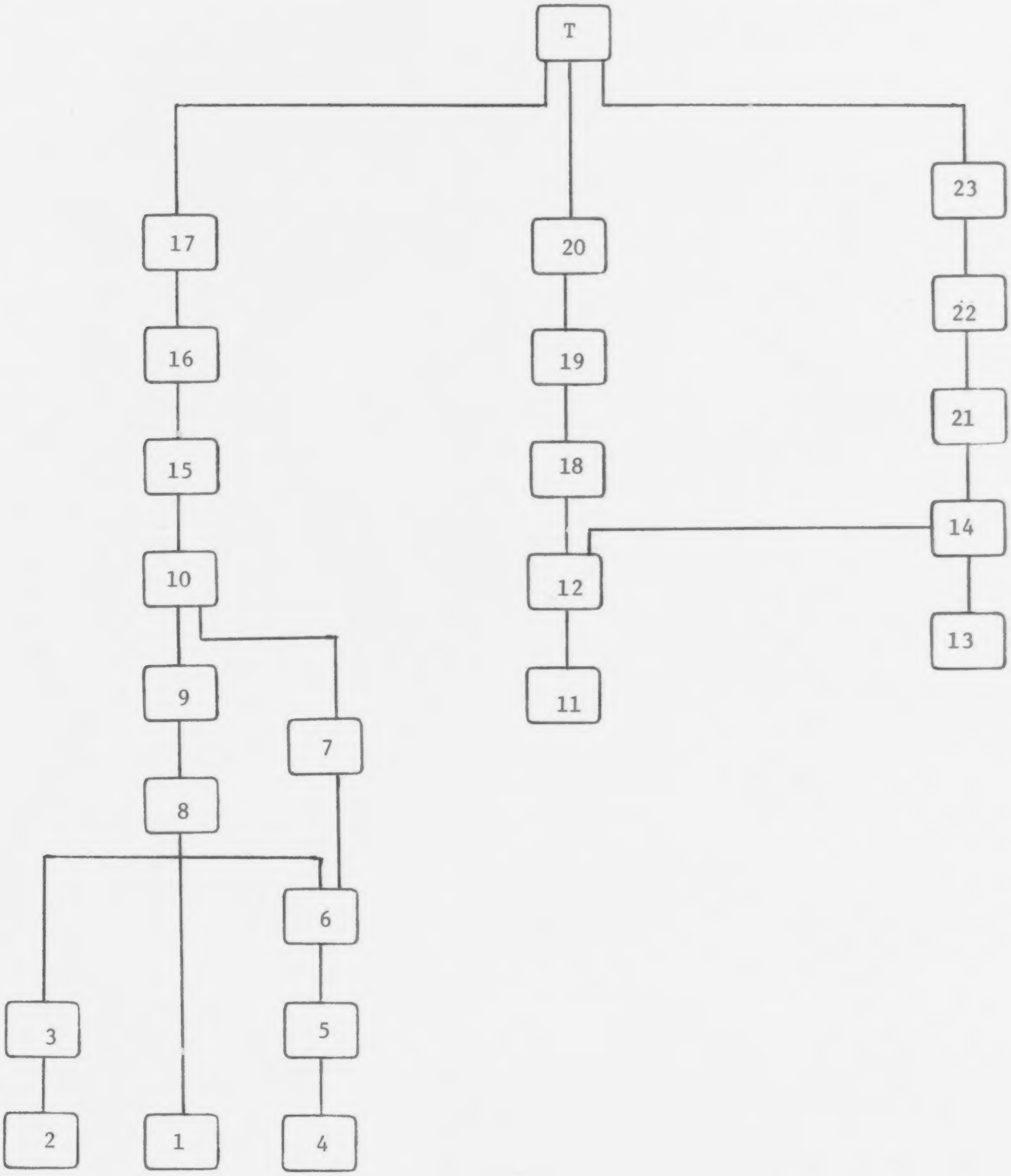
20. Given a square measurement, the student constructs an equivalent by using factors of the multiplicative identity.

21. Given a list of mathematical expressions, the student identifies those expressions which contain three fractional numerals consisting of denominate numbers and names the multiplicative identity.

22. The student constructs the multiplicative identity as the product of three fractional numerals consisting of denominate numbers.

23. Given a cubic measurement, the student constructs an equivalent using factors of the multiplicative identity.

DIMENSIONAL ANALYSIS-HIERARCHY


T
17
20
23
22
16
19
21
15
18
14
10
12
13
9
11
7
8
6
3
5
2
1
4

Pretest

1. 361 milligrams = ? grams
2. 264 feet per second = ? miles per hour
3. .7 cubic meters = ? cubic centimeters
4. If 41 macs = 1 am and macs and ams measure length, 336.2 square macs = ? square ams.

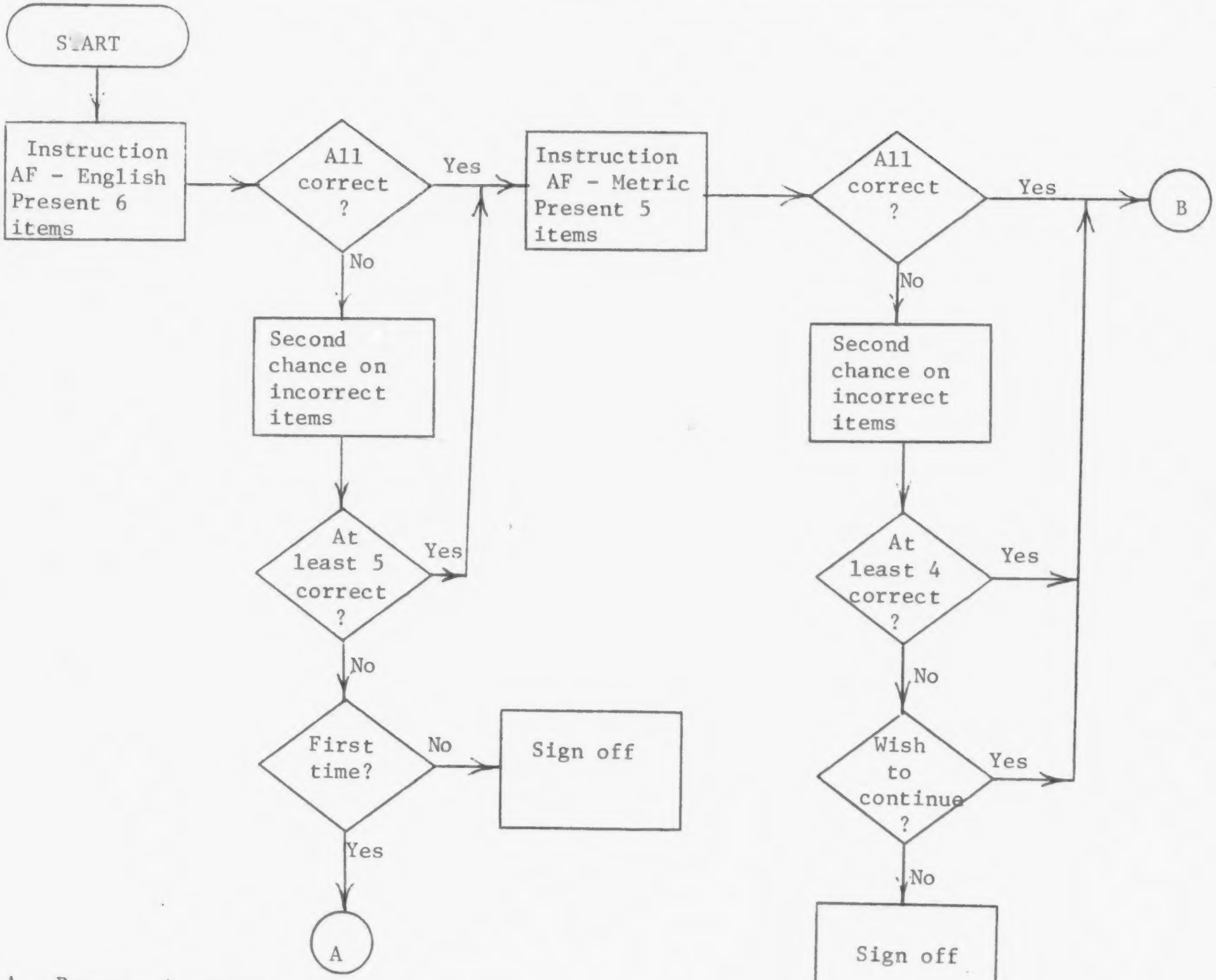
Posttest

1. 72 ounces = ? pounds
2. 150 miles per hour = ? yards per second (to the nearest tenth of a yard)
3. 4210 square meters = ? square kilometers
4. .3 cubic miles = ? cubic feet (Show how to do the problem. You do not have to get the answer.)

Mode of Presentation

Provided with tables of measurement, the student interacts with the program by using a CRT terminal with keyboard. Use of the light pen is not required.

DIMENSIONAL ANAYSIS - EXCERPT FROM INSTRUCTIONAL STRATEGY


START
Instruction AF - English Present 6 items
All correct ?
Yes
No
Second chance on incorrect items
At least 5 correct ?
Yes
No
First time?
No
Sign off
Yes
A
Instruction AF - Metric Present 5 items
All correct ?
Yes
B
No
Second chance on incorrect items
At least 4 correct ?
Yes
No
Wish to continue ?
Yes
No
Sign off

A - Repeats instruction
B - Continues in program

DIMENSIONAL ANALYSIS – POSSIBLE PATHS FROM DIAGNOSTIC TEST

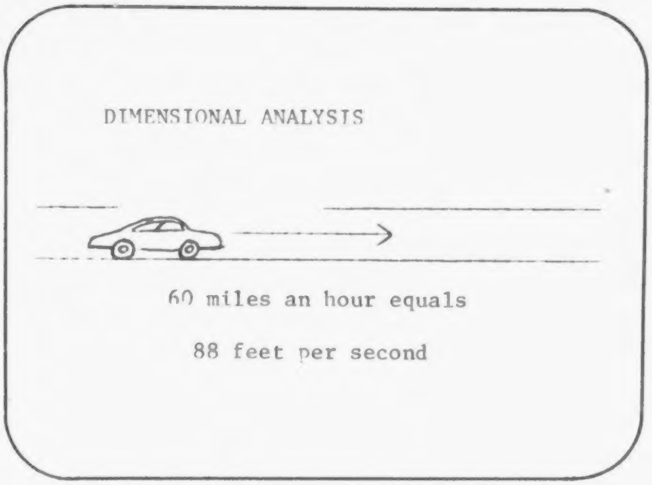
Number of Questions Necessary To Make Diagnosis	Path of Diagnostic Test	Actual Diagnosis	Path for Instruction
7	8(1), 8(2), 8(3), 8(4). 11a, 11b, 11c	works accurately with one, two, three-dimensional conversions and with rates	A
8	8(1), 8(2), 8(3), 8(4), 11a, 11b, 11c, 10c	completes complicated conversion fractions for cubic measures	B
9	8(1), 8(2), 8(3), 8(4), 11a, 11b, 11c, 10c, 4c	identifies cubic units = M x M x M	C
10	8(1), 8(2), 8(3), 8(4), 11a, 11b, 11c, 10c, 4c, 3c (correct)	identifies units of volume	D
10	8(1), 8(2), 8(3), 8(4), 11a, 11b, 11c, 10c, 4c, 3c (incorrect)	does not identify units of volume	E
7	8(1), 8(2), 8(3), 8(4), 11a, 11b, 10b	completes conversion fractions for square measures	F
8	8(1), 8(2), 8(3), 8(4), 11a, 11b, 10b, ab	knows square measure = M x M	G
9	8(1), 8(2), 8(3), 8(4), 11a, 11b, 10b, 2b, 1e (correct)	identifies units of area	H
9	8(1), 8(2), 8(3), 8(4), 11a, 11b, 10b, 2b, 1e (incorrect)	does not identify units of area	I
6	8(1), 8(2), 8(3), 8(4), 11a, 10a	writes rate as a fraction	J
7	8(1), 8(2), 8(3), 8(4), 11a, 10a, 9a (correct)	identifies rates	K

Number of Questions Necessary to Make Diagnosis	Path of Diagnostic Test	Actual Diagnosis	Path for Instruction
7	8(1), 8(2), 8(3), 8(4), 11a, 10a, 9a (incorrect)	does not identify rates	L
4	8(1), 8(2), 8(3), 8(4)	can convert one-dimensional measures but needs practice	M
5	8(1), 8(2), 6, 7, 8z (correct)	completes conversion fractions for one-dimensional measures	N
5	8(1), 8(2), 6, 7, 8z (incorrect)	does not complete above conversion of fractions correctly	O
4	8(1), 8(2), 6, 7	cannot form fractions of denominate numbers but knows identity using denominate numbers	P
6	8(1), 8(2), 6, 1d (correct), 1c (correct)	can demonstrate the use of tables of measurements and identify the multiplicative identity in fractional form	Q
6	8(1), 8(2), 6, 1d (incorrect), 1c (correct)	can identify the multiplicative identity in fractional form but cannot demonstrate the use of tables of measurement	R_1
5	8(1), 8(2), 6, 1d, 1c (incorrect) 1b (correct)	can name multiplicative identity	S
5	8(1), 8(2), 6, 1d, 1c (incorrect), 1b (incorrect)	cannot name multiplicative identity	T
7	8(1), 8(2), 6, 1d (incorrect), 1c (incorrect), 1b (correct)	names multiplicative identity but cannot read tables of measurement	R_2
7	8(1), 8(2), 6, 1d (incorrect), 1c (incorrect), 1b (incorrect)	cannot name the identity nor read tables of measurement	R_3

DIMENSIONAL ANALYSIS – PATHS OF INSTRUCTION

Path	Instruction Frames
A	A1, 61 –––
B	E1, B1, 57 –––
C	E1, E6-10, 56 –––
D	E1, E6-10, 55 –––
E	E1-10, 55 –––
F	I1, E6-9, 49 –––
G	I1, E6-9, 47 –––
H	I1, E6-9, 45 –––
I	I1-4, E6-9, 45 –––
J	L1, L2, E7-9, K1, 35 –––
K	L1, L2, E7-9, K1, 34 –––
L	L1, L2, E7-9, 33 –––
M	M1, E7-9, 26 or M1, M2, 26 –––
N	1, 7, 12, 21 –––
O	1, 7, 12 –––
P	1, 9 –––
Q	1, 7 –––
R_1	R1-4, 1, 7 –––
S	2 –––
T	1 –––
R_2	R1-4, 2 –––
R_3	R1-4, 1 –––

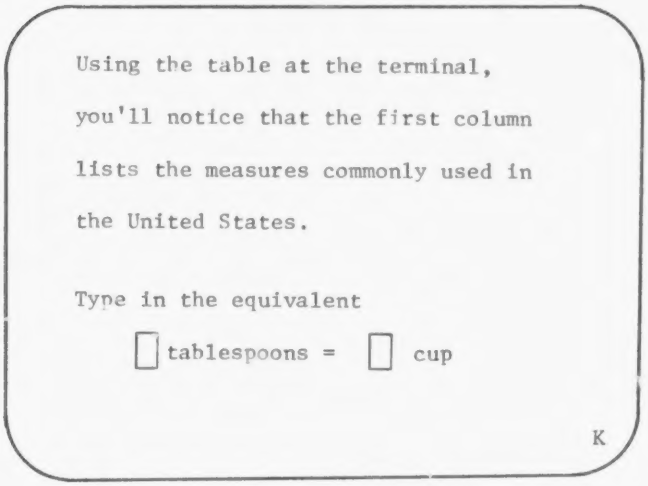
Sample Section of Program



DIMENSIONAL ANALYSIS

60 miles an hour equals

88 feet per second



Using the table at the terminal,

you'll notice that the first column

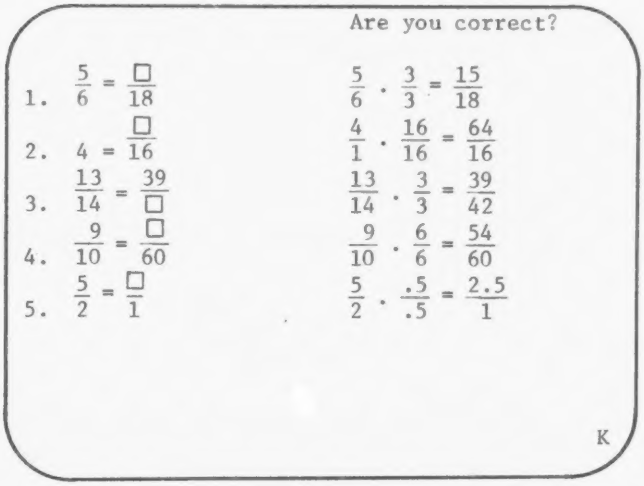
lists the measures commonly used in

the United States.

Type in the equivalent

☐ tablespoons = ☐ cup

K



Are you correct?

1. $\frac{5}{6} = \frac{\square}{18}$ $\frac{5}{6} \cdot \frac{3}{3} = \frac{15}{18}$

2. $4 = \frac{\square}{16}$ $\frac{4}{1} \cdot \frac{16}{16} = \frac{64}{16}$

3. $\frac{13}{14} = \frac{39}{\square}$ $\frac{13}{14} \cdot \frac{3}{3} = \frac{39}{42}$

4. $\frac{9}{10} = \frac{\square}{60}$ $\frac{9}{10} \cdot \frac{6}{6} = \frac{54}{60}$

5. $\frac{5}{2} = \frac{\square}{1}$ $\frac{5}{2} \cdot \frac{.5}{.5} = \frac{2.5}{1}$

K

Area is used in case you wish to:

(a) Tile a floor.

(b) Paint the walls of a room.

(c) Buy a rug.

(d) Pave a walk.

S

A rate always means division

30 miles per hour

means

30 miles divided by 1 hour

$$\frac{30 \text{ miles}}{1 \text{ hour}}$$

S

45 miles per hour = ☐ kilometers per hour

$$\frac{45 \text{ miles}}{1 \text{ hour}} \cdot \frac{1.61 \text{ km}}{1 \text{ mile}} = 72.5 \text{ kilometers per hour}$$

K

Comments

This program was originally used in the summer of 1969 with students who planned to take physics and chemistry that coming fall. Offered as an elective summer school course, Dimensional Analysis was open to those students who, having been pretested, showed a deficiency in analysis of dimensional translations.

c. SLOPE OF THE LINE

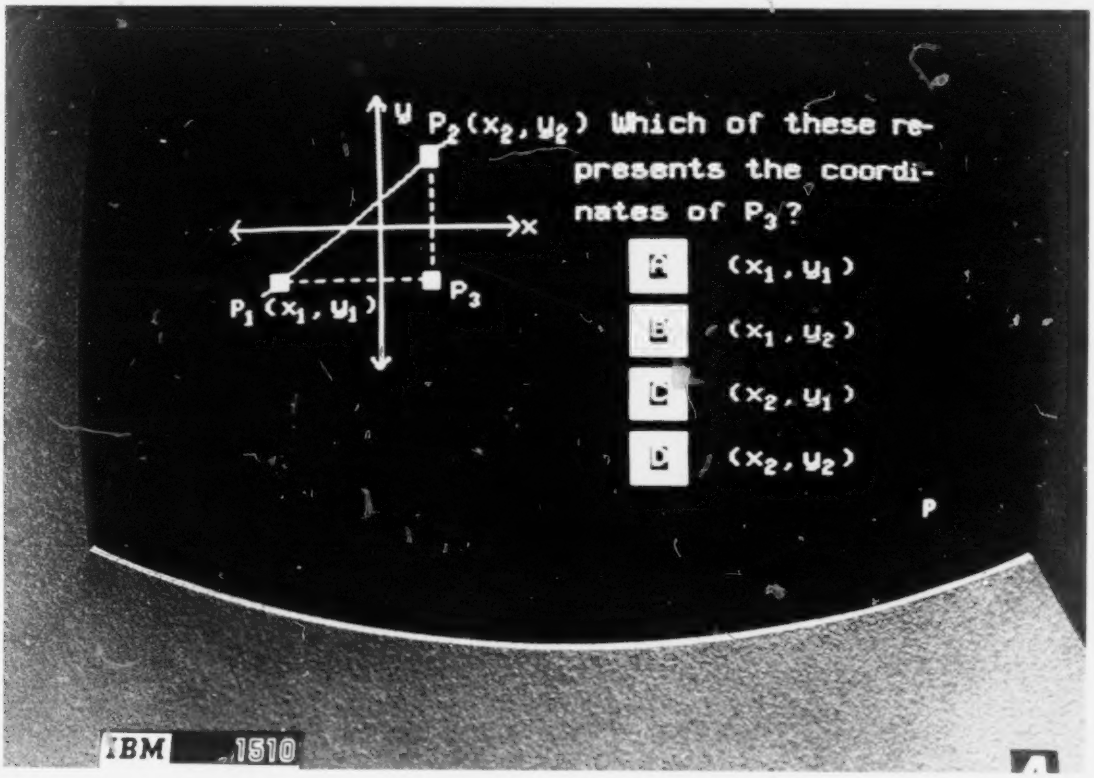
Assessment of Need

A unit in algebra courses requiring instruction with varying amounts of practice is that relating to the slope of the line concept. Usually, the time allotted in the classroom is insufficient for most students to acquire the behaviors desired. With these considerations in mind, two members of the mathematics design team Joan Piersol, Gaithersburg Senior High School, and Merrill Fisher, Bethesda-Chevy Chase High School, wrote a CAI instructional segment. The segment was coded in COURSEWRITER II by Anne Metzger, project programmer.

Description of Program

The authors designed a pretest and a posttest which were given off-line. Enabling objectives were then written, and a hierarchy of these objectives prepared.

The segment begins with a five-item test on entering behaviors identified as prerequisites for this unit. If the student fails to meet the predetermined level of success on this test, he is referred to his instructor with a checklist, describing the skills and concepts he has and those he needs to review.



Which of these represents the coordinates of P_3?

A (x_1, y_1)
B (x_1, y_2)
C (x_2, y_1)
D (x_2, y_2)

Terminal Objective

The terminal objective of this unit is:

> Given a linear equation or the graph of a linear equation, the student names the slope of the line.

Entering Behaviors

1. Given two equations in the form ax + by = 0 or ax + by = c, the student solves at least one equation for y in terms of x.
2. Given an equation in the form ax + by = c, and four values for x, the student constructs at least three values for y.
3. Given a grid and the coordinates for four points, the student graphs at least three points.
4. Given a grid and four points graphed thereon, the student constructs the coordinates for at least three points.

Enabling Objectives

1. Given a linear equation or the graph of a linear equation, the student names the slope of the line.
2. Given the graph of a linear equation, and at least two ordered pairs contained on this graph, the student determines the slope.
3. Given a linear equation written in the form of ax + by = c, the student identifies its graph.
4. Given a linear equation written in the form of y = mx + b, the student identifies its graph by using the slope and the y-intercept.
5. Given a linear equation written in the form of ax + by = c, the student determines its slope and y-intercept.
6. Given a linear equation, the student names both the slope of the line and the y-intercept.
7. Given a linear equation written in the form of y = mx + b, the graph of this equation, and several ordered pairs satisfying this equation, the student names the relationship which exists between the coefficient of x and the graph of the equation, and the relationship which exists between the constant and the graph.
8. The student states the definitions for x-intercepts and y-intercepts.
9. Given a linear equation in the form y = mx + b or ax + by = c, the student determines x when y = 0 and determines y when x = 0.
10. The student identifies the graph of a linear equation.
11. The student states a definition of slope.

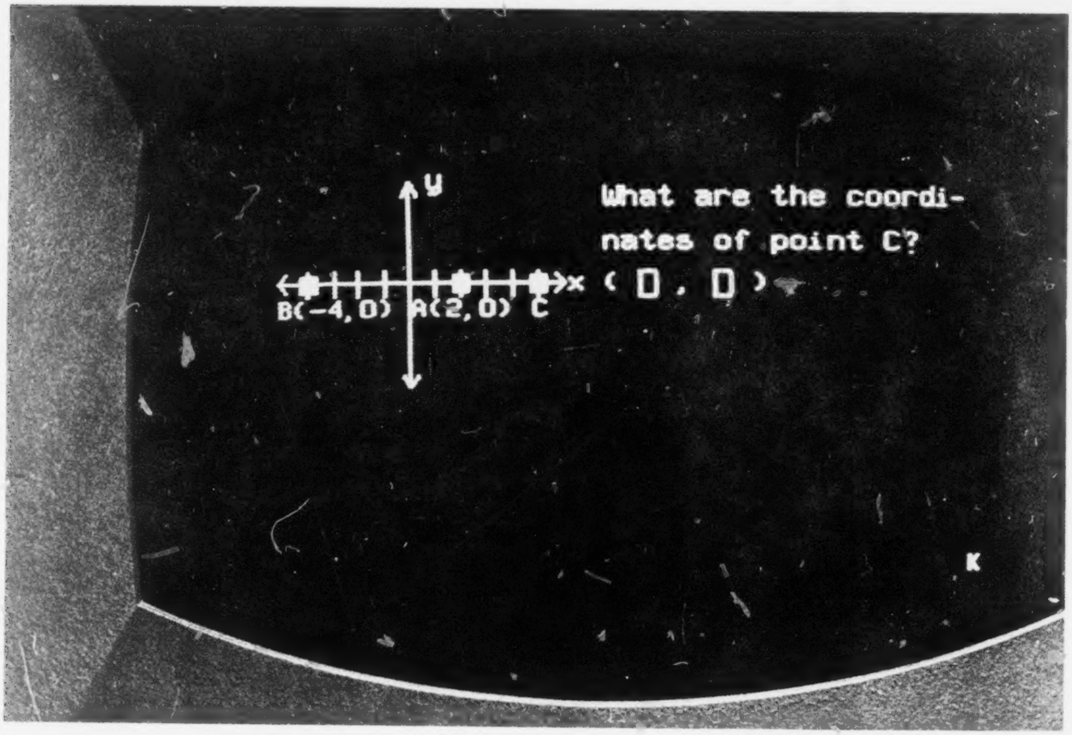
12. The student identifies linear equations.

13. Given a linear equation, the student states that the equation has an infinite number of ordered pairs as solutions and that the graph of these points forms a straight line.

14. Given at least two ordered pairs for a linear equation, the student names the ratio of the vertical change to the horizontal change.

15. The student states a definition for a linear equation.

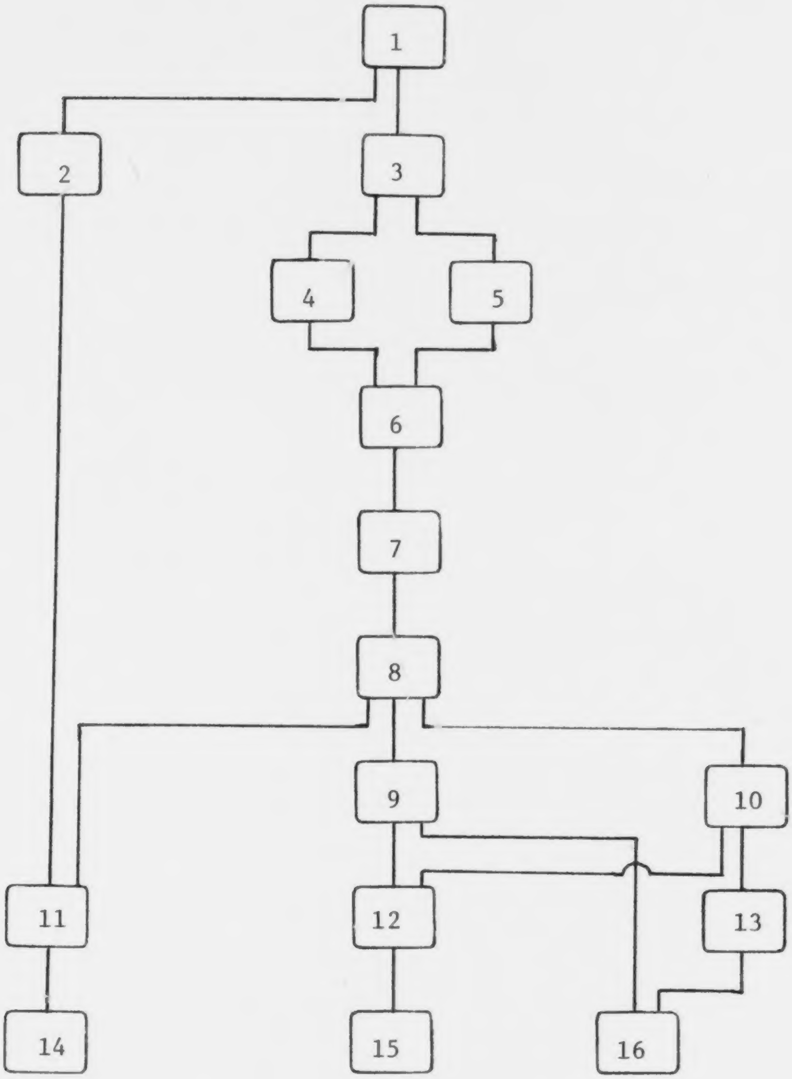
16. Given a linear equation and fixed x values, the student determines the corresponding y values and plots these points on the graph.



What are the coordinates of point C?

(☐ , ☐)

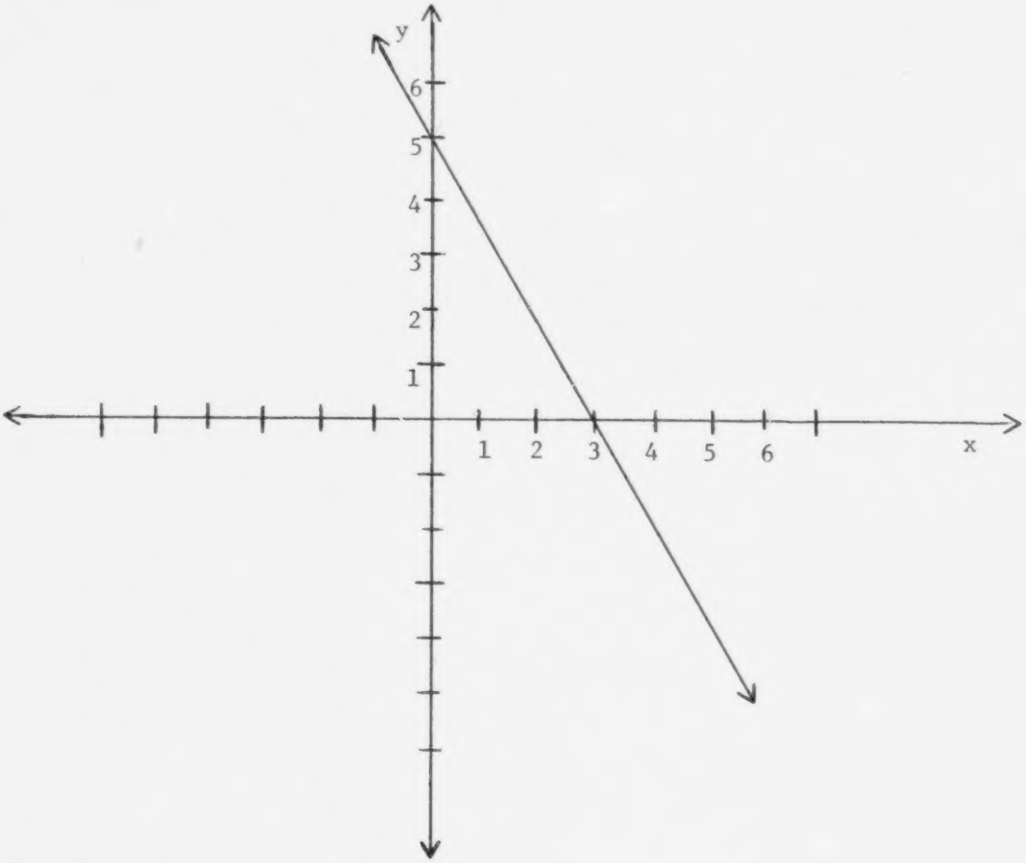
SLOPE OF THE LINE - HIERARCHY


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Pretest

10.1 What is the slope of the line whose equation is $5x + 6y = 10$?

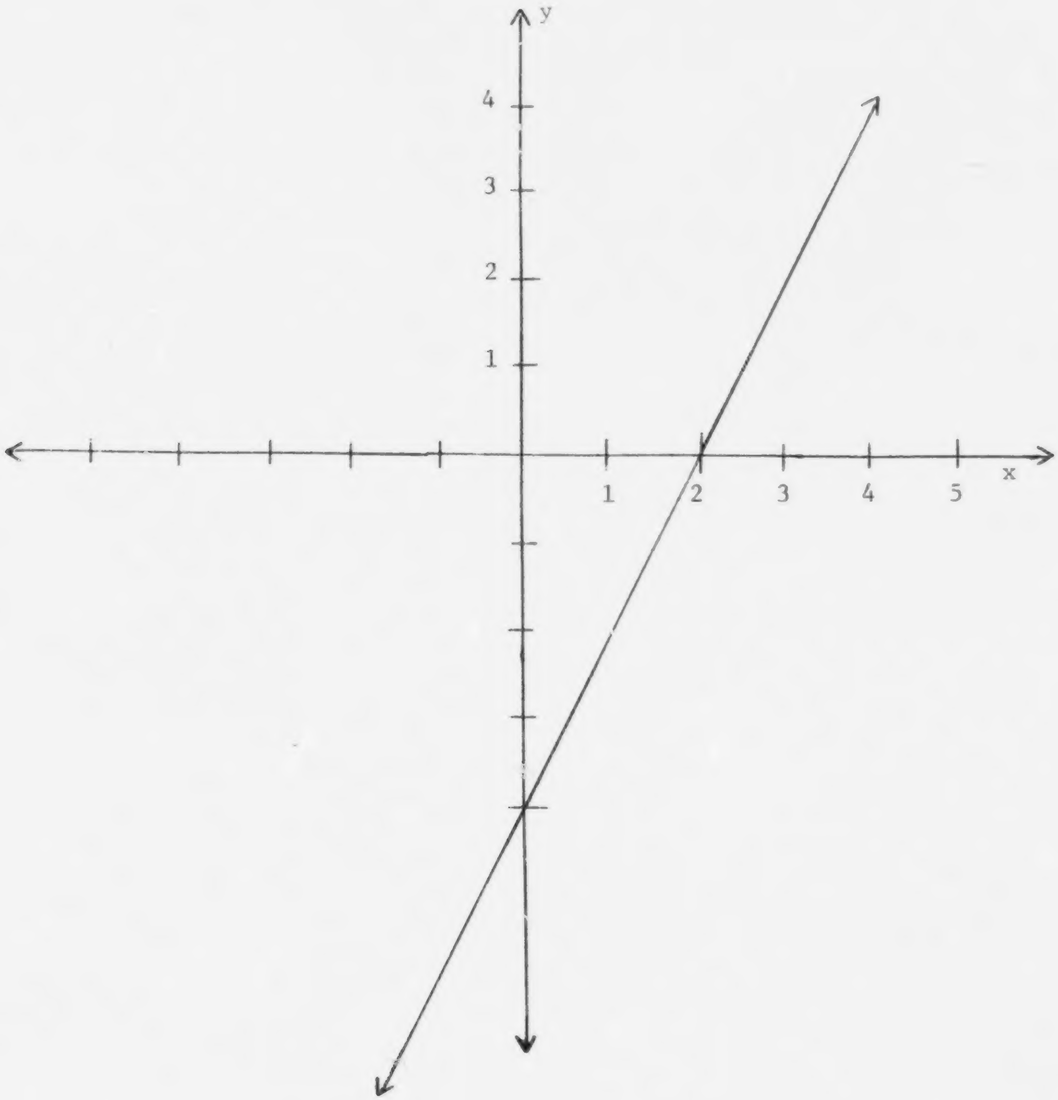
10.2 What is the slope of the line graphed on this grid?



Posttest

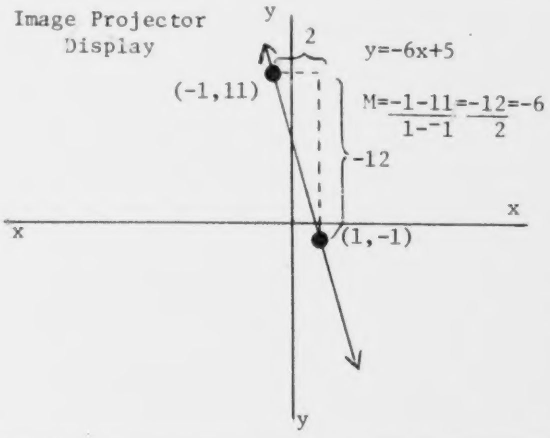
1. What is the slope of the line whose equation is $6x - 9y = 10$?

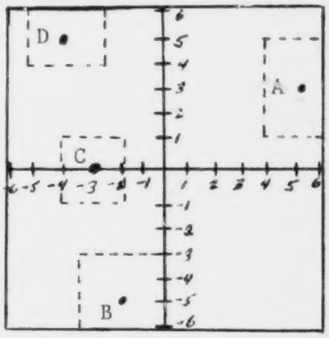
2. What is the slope of the line graphed on this grid?



Sample Section of Program

Image Projector
Display


y
2
y=-6x+5
(-1,11)
$M=\frac{-1-11}{1-^{-}1}=\frac{-12}{2}=-6$
-12
x
x
(1,-1)
y


D
A
C
B
6
5
4
3
2
1
-1
-2
-3
-4
-5
-6
-6 -5 -4 -3 -2 -1
1 2 3 4 5 6

4. On the graph shown, locate the following points in order:

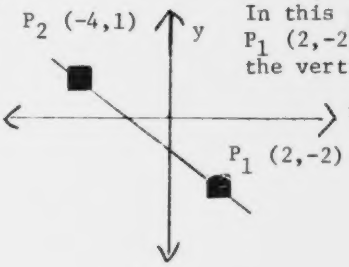
A: (5, +3)

B: (-2, -5)

C: (0, -3)

D: (-4, 5)

P


P_2 (-4,1)
y
x
P_1 (2,-2)

In this example with P_1 (2,-2) and P_2 (-4,1) the vertical change Y_2-Y_1 is 3 and the horizontal change X_2-X_1 is -6.

What is the value of $Y_1 -Y_2$?

What is the value of $X_1 -X_2$?

Mode of Presentation

Slope of the Line is a tutorial unit in which the student's involvement is continuous. It employs the 1510 Instructional Display with keyboard and light pen, using either the 1512 Image Projector or flipbook.

Instructional Strategy

Once a student has satisfactorily completed the entering behaviors test, he then begins continuous involvement in this tutorially designed unit on slope of the line. This program may provide remediational loops when difficulty with a concept area arises, or it may allow student choices of alternative paths.

Comments

This segment was initially pilot tested at Einstein High School with six students in the summer of 1969. Subsequent to this testing, some revisions in text and reinforcement were made. Further pilot testing during the fall semester of 1969 allowed for additional debugging. By the fall semester of 1970, it was felt that the program was ready for large-scale student use; a validation study conducted that semester involving fifty-five students supported this view.

Slope of the Line has since been used with Algebra I and Algebra II students as primary instruction on the concept. The MIP has also provided remedial instruction for students in geometry, Algebra II, and Advanced Algebra and Trigonometry.

d. RADICAL REVIEW

Assessment of Need

This drill and practice program is intended for use by Algebra II students as a review of several concepts involving radicals. Need for such review was identified by teachers who felt that ample time was not generally spent in the Algebra I curriculum to allow students the opportunity to master these skills.

Description of the Program

The drill and practice session is divided into five areas involving operations with radical expressions.

(1) Simplifying radicals containing no variables

(2) Simplifying radicals containing variables

(3) Forming the product of two or more radicals and simplifying results

(4) Forming the sum or difference of two or more radicals and simplifying results

(5) Simplifying radicals with binomial denominators

Radical Review was authored by Eleanor Lautenschlager, Thomas E. Robinson, and Catherine Morgan. Priscilla Smith programmed the MIP in COURSEWRITER II. It was completed and pilot tested at Einstein High School in the fall of 1970.

Terminal Objective

The student completes a review of simplifying radical expressions:

(1) Radicals containing no variables

(2) Radicals containing variables

(3) The product of two or more variables

(4) The sum or difference of two or more radicals

(5) Radicals with binomial denominators

Entering Behaviors

1. Given a list of numerals, the student identifies them as:

    a. Numerals representing rational numbers

    b. Numerals representing irrational numbers

    c. Numerals representing neither rational nor irrational numbers

2. Given a rational number written in radical form, the student names the nonnegative square root as simplest form.

3. Given any positive integral number, the student factors it into prime numbers.

Enabling Objectives

1a) Given a nonnegative rational number written in radical form, the student writes the number in simplest form.

1b) Given a single term integral radical expression representing a real number, the student writes it in simplest form.

1c) Given a single term radical expression representing a real number and with a radical in the denominator, the student writes it in simplest form with a rational denominator.

1d) Given a single term radical expression with a fractional numeral under the radical sign and representing a real number, the student writes it in simplest form with a rational denominator and no fractional-numeral under the radical sign.

1e) Given any single term irrational number written in radical form, the student writes the number in simplest form. (Expression will contain no variable.)

2.) Given any single term expression in radical form containing one or more variables and representing a real number, the student writes it in simplest form, using absolute value symbols where necessary.

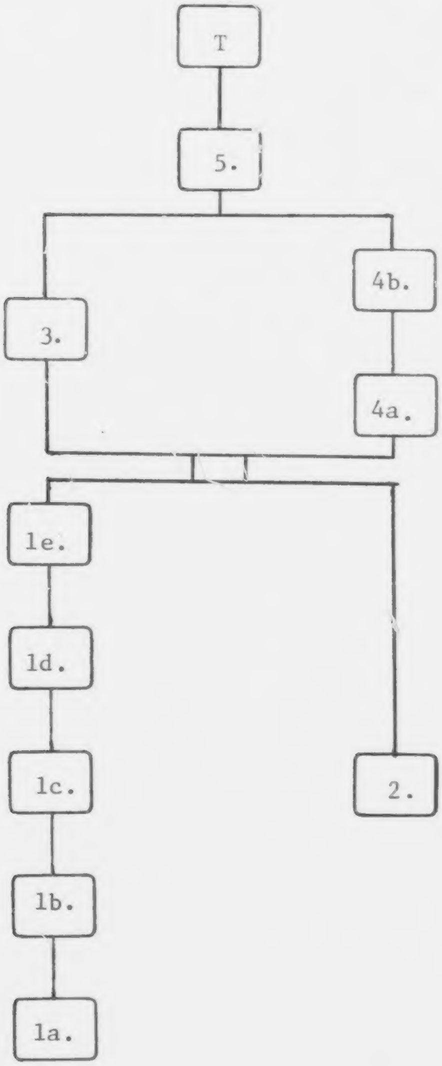
3.) Given two or more expressions, at least one in radical form, and representing real numbers, the student writes the product in simplest form. (If expressions contain variables, the student uses absolute value symbols where applicable.)

4a) Given two or more expressions in radical form and representing real numbers, the student writes their sum. (If expressions contain variables, the student uses absolute value symbols where applicable.)

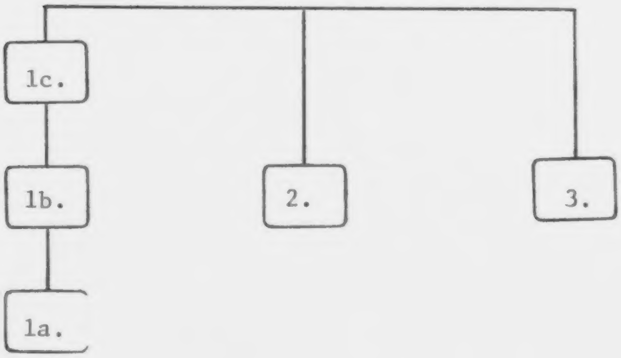
4b) Given two or more expressions in radical form and representing real numbers, the student writes their difference. (If expressions contain variables, the student uses absolute value symbols where applicable.)

5.) Given any fractional expression representing a real number, and with a binomial denominator with at least one term containing a radical, the student writes it in the simplest form with a rational denominator.

RADICAL REVIEW - HIERARCHY


T
5.
3.
4b.
4a.
1e.
1d.
1c.
1b.
1a.
2.

ENTERING BEHAVIORS



Pretest – Postest

Neither pretest nor posttest exists for this unit. At the end of each drill section, however, the individual student's score board has proven useful for teacher analysis.

Mode of Presentation

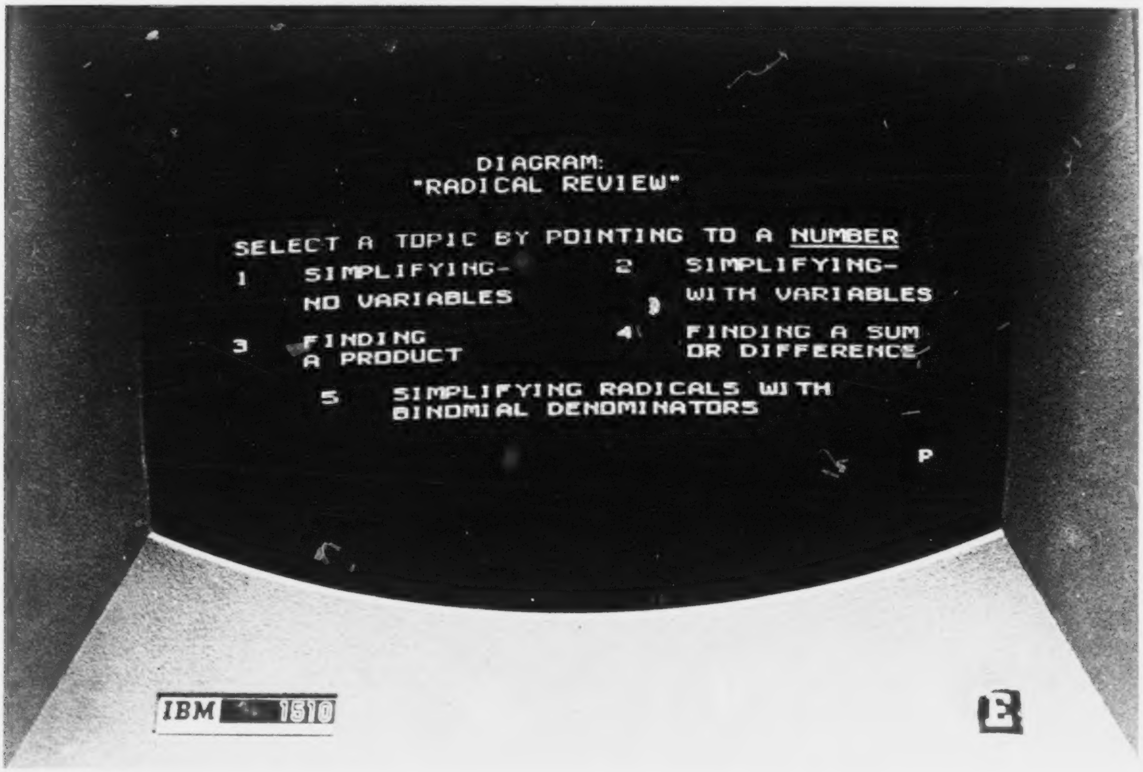
The student, using an IBM 1510 Instructional Display with light pen, may choose sections in any order and work through them as many times as he wishes to improve his score. The problems in each section are randomly generated, so that when a student returns to a section, he does not receive the same problems.

As he completes each section, the student is given an analysis of his score. He may then choose to:

1) Continue to the next section

2) Go back to a previously worked section

3) Sign off and seek help from his instructor



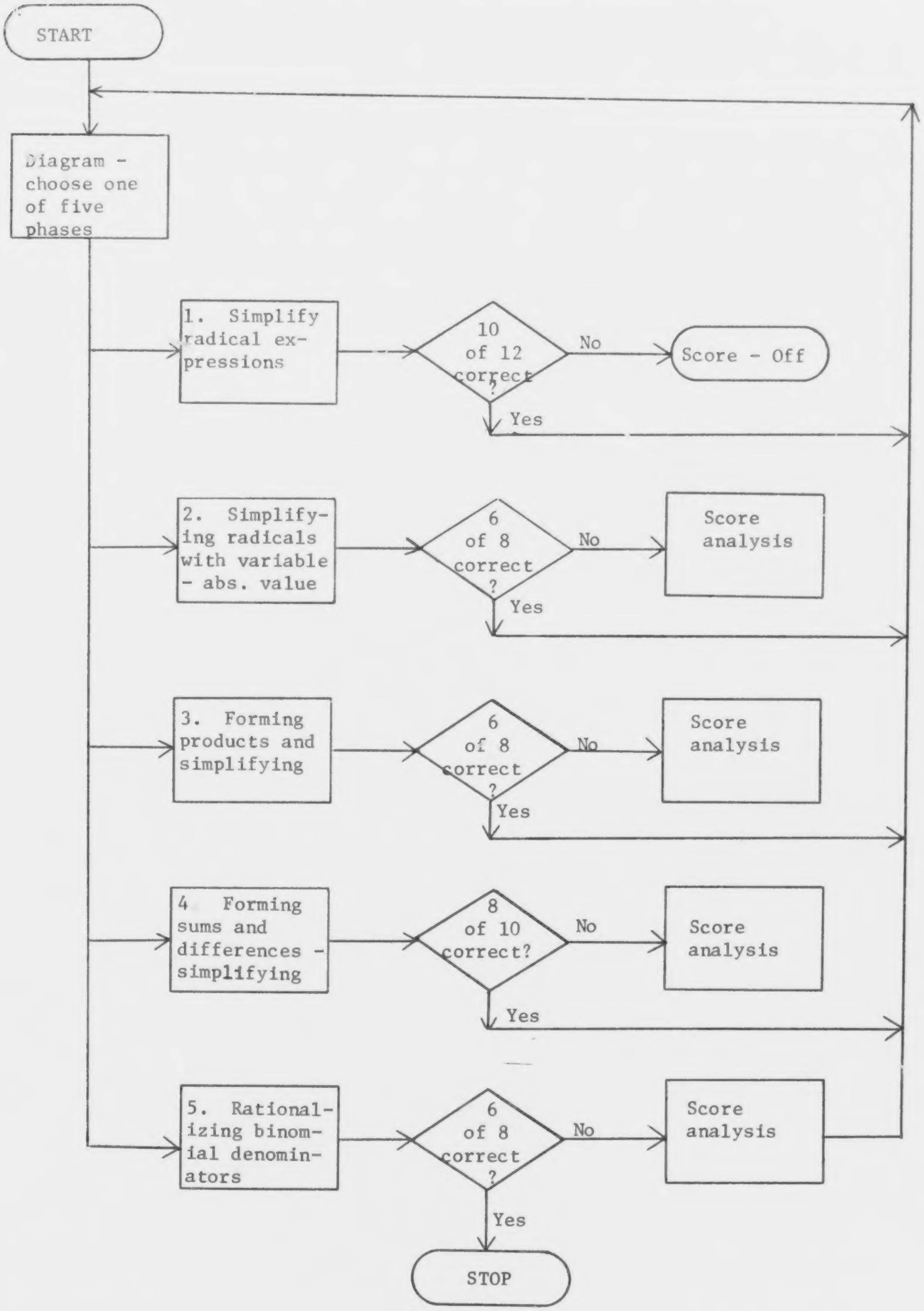
```
                 DIAGRAM:
             "RADICAL REVIEW"

SELECT A TOPIC BY POINTING TO A NUMBER
1    SIMPLIFYING-           2    SIMPLIFYING-
     NO VARIABLES                WITH VARIABLES

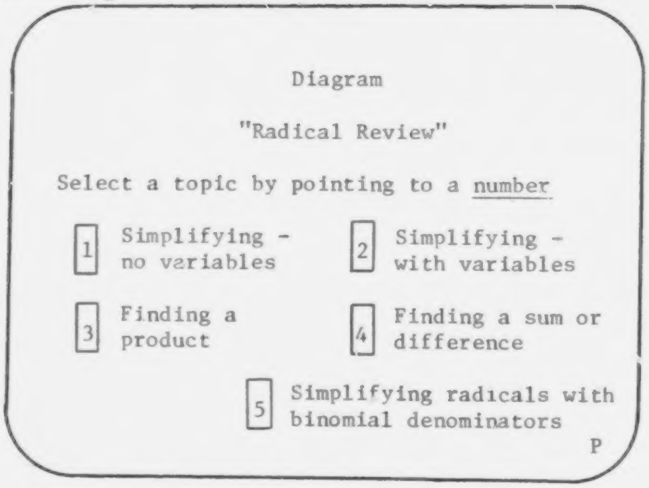
3    FINDING                4    FINDING A SUM
     A PRODUCT                   OR DIFFERENCE
        5    SIMPLIFYING RADICALS WITH
             BINOMIAL DENOMINATORS

                                           P
```

RADICAL REVIEW - INSTRUCTIONAL STRATEGY


START
Diagram - choose one of five phases
1. Simplify radical expressions
10 of 12 correct ?
No
Score - Off
Yes
2. Simplifying radicals with variable - abs. value
6 of 8 correct ?
No
Score analysis
Yes
3. Forming products and simplifying
6 of 8 correct ?
No
Score analysis
Yes
4 Forming sums and differences - simplifying
8 of 10 correct?
No
Score analysis
Yes
5. Rationalizing binomial denominators
6 of 8 correct ?
No
Score analysis
Yes
STOP

Sample Section of Program



Diagram

"Radical Review"

Select a topic by pointing to a number

☐ 1 Simplifying - no variables

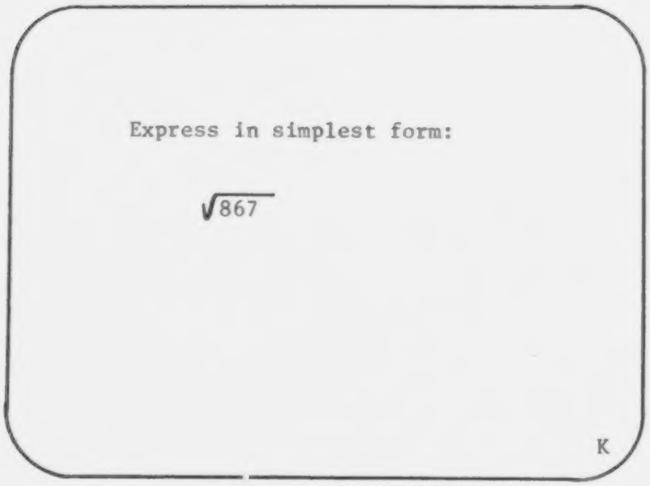
☐ 2 Simplifying - with variables

☐ 3 Finding a product

☐ 4 Finding a sum or difference

☐ 5 Simplifying radicals with binomial denominators

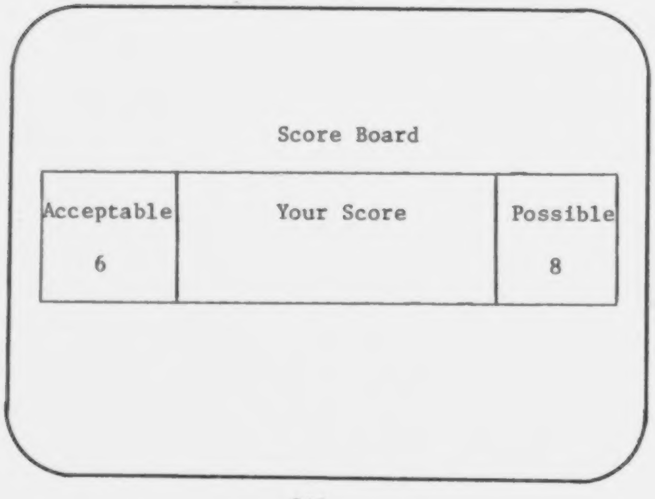
P



Express in simplest form:

$\sqrt{867}$

K



Score Board

Acceptable	Your Score	Possible
6		8

Comments

Extensive pilot testing of Radical Review revealed the need for additional alternate correct answers. Students using the program provided the authors with valuable information for revising the program in this area.

e. FACTORING

Assessment of Need

Factoring is an area in elementary algebra for which a wide variety of learner needs exists. It is an essential skill for progress in basic algebra and is therefore a fundamental concept for computations using algebraic fractions and solving fractional quadratic equations. Students unable to master factoring skills find their progress in algebra seriously impaired.

Description of Program

This student controlled sequence combines the techniques of tutorial dialogue with drill and practice. Following instruction on a concept level, the student has ample opportunities to master the acquired skill through practice. As he proceeds through the program, he utilizes the 1510 Instructional Display with light pen and a student booklet which describes each objective. This MIP was authored by Catherine E. Morgan in the fall of 1969 and coded into COURSEWRITER II by Chris Eshleman and Steve Swanson.

Terminal Objective

Given ten polynomials with integral coefficients whose terms

(1) may have common numerical and/or variable factors and

(2) which, after factoring for common factors, contain no variable with exponents greater than two,

the student factors completely over the set of polynomials with integral coefficients.

Entering Behaviors

A. The student factors natural numbers into primes.

B. The student multiplies polynomials.

C. The student divides polynomials.

Enabling Objectives

1a. The student identifies the factors of an integer as those integers which divide it with a zero remainder.

1b. The student identifies an integer as completed factored when all the factors are prime numbers except for -1.

1c. The student factors an integer completely.

2a. The student identifies factors of a monomial as those monomials which divide it with a zero remainder.

2b. The student identifies a monomial as completed factored when no factor can be factored further.

2c. The student factors a monomial completely.

3. The student identifies the factors of a polynomial as those polynomials which divide it with a zero remainder.

4a. Given a polynomial of more than one term and list of possible factors, one monomial and one polynomial with more than one term, the student identifies the correct factors.

4b. Given a polynomial of more than one term and its greatest common monomial factor, the student identifies the other factor.

4c. Given a polynomial of more than one term and its greatest common monomial factor, the student writes the other factor.

5a. Given a polynomial of more than one term, the student identifies the common factors.

5b. Given a polynomial of more than one term, the student names the common monomial factors.

5c. Given a polynomial of more than one term, the student identifies the greatest common monomial factor.

5d. Given a polynomial of more than one term, the student writes its greatest common monomial factor.

6a. Given a list of two and three term polynomials with no common monomial factors, the student matches with the correct factors.

6b. Given one factor of a polynomial of two or three terms and no common monomial factor, the student identifies the second factor.

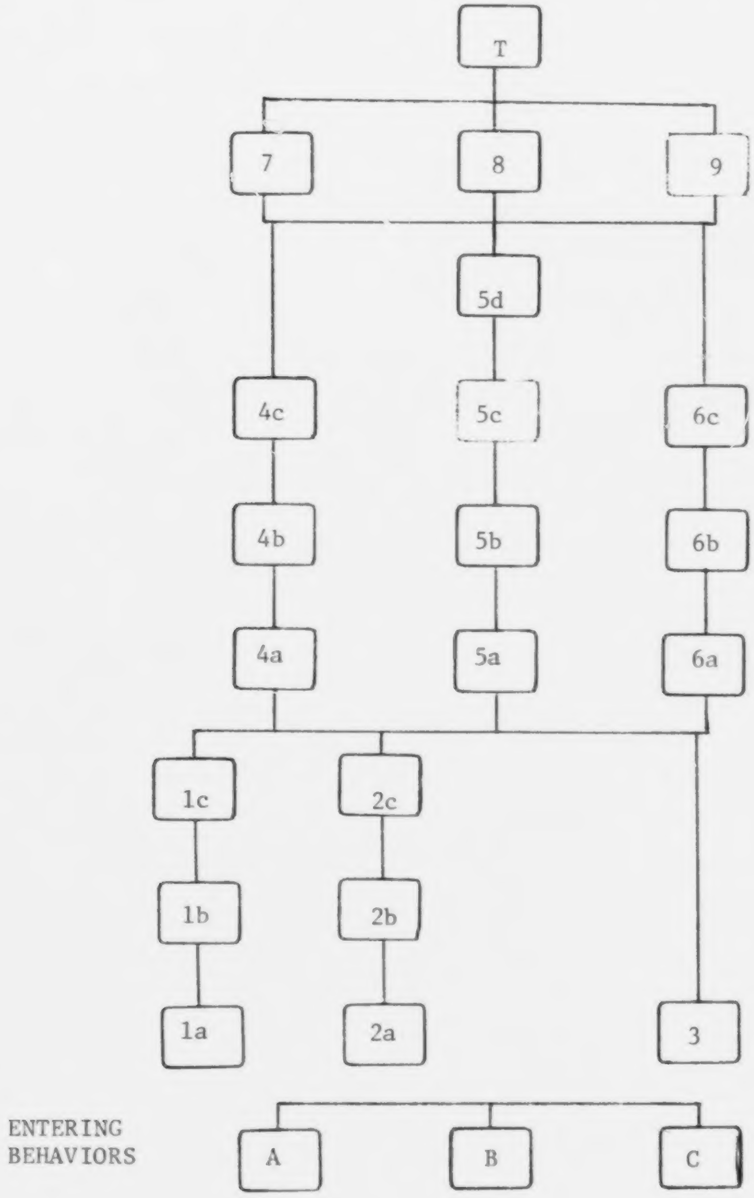
6c. Given one factor of a polynomial of two or three terms and no common monomial factor, the student writes the second factor.

7. Given a polynomial with exactly two binomial factors, the student lists possible factorizations and identifies the correct factors.

8. The student identifies a polynomial as completely factored when no factor can be factored further.

9. Given a factorable polynomial of no more than three terms, with rational integral coefficients and whose terms have common factors, the student factors into the greatest common monomial factor and a polynomial.

FACTORING - HIERARCHY


T
7
8
9
5d
4c
5c
6c
4b
5b
6b
4a
5a
6a
1c
2c
1b
2b
1a
2a
3
ENTERING BEHAVIORS
A
B
C

Pretest

1. $x^3 - x^2 - 6x$
2. $2x^2 - 18$
3. $y^2 + 8y + 16$
4. $a^2 - 36$
5. $x^2 - 3x - 10$
6. $y^2 - 3y - 28$
7. $x^4 - 4x^2$
8. $3a^2 - 30a + 75$
9. $y^3 - 8y^2 + 12y$
10. $-2x^3 + 18x$

Posttest

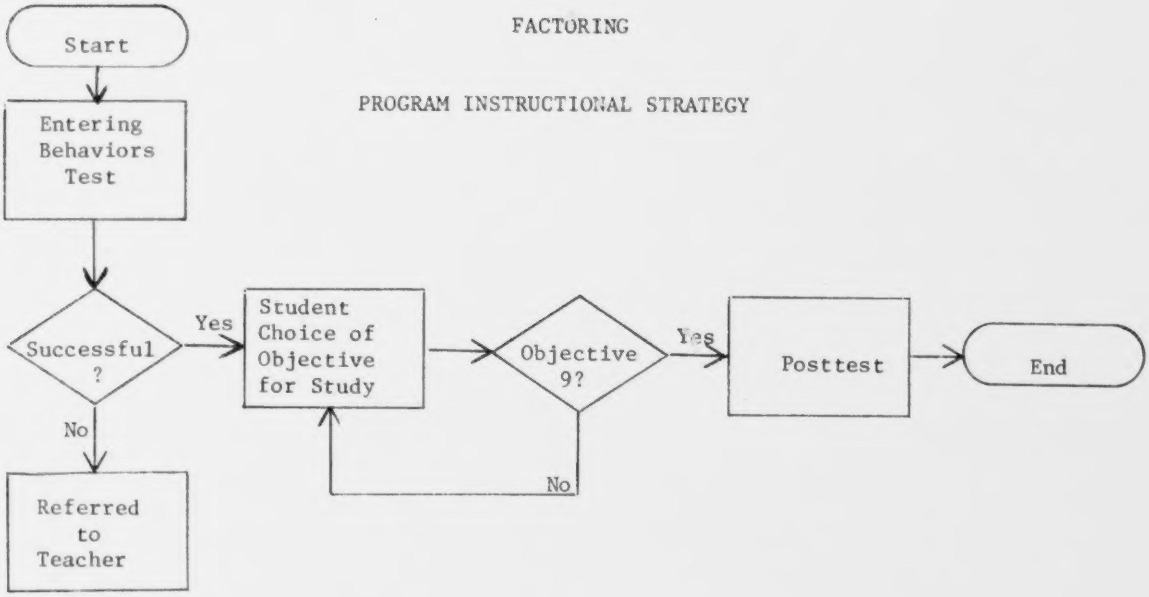
1. $3x^2 + 12x + 12$
2. $x^2 - x - 72$
3. $9x^2 - 25y^2$
4. $st^2 - 3st - 40s$
5. $12m^2 + 3n^2$
6. $3x^2 + 5x - 2$
7. $2y^2 - 28y + 98$
8. $-x^2 + 2x + 8$
9. $5x^2 - 16xy + 3y^2$
10. $6a^2 - 13a - 63$

Mode of Presentation

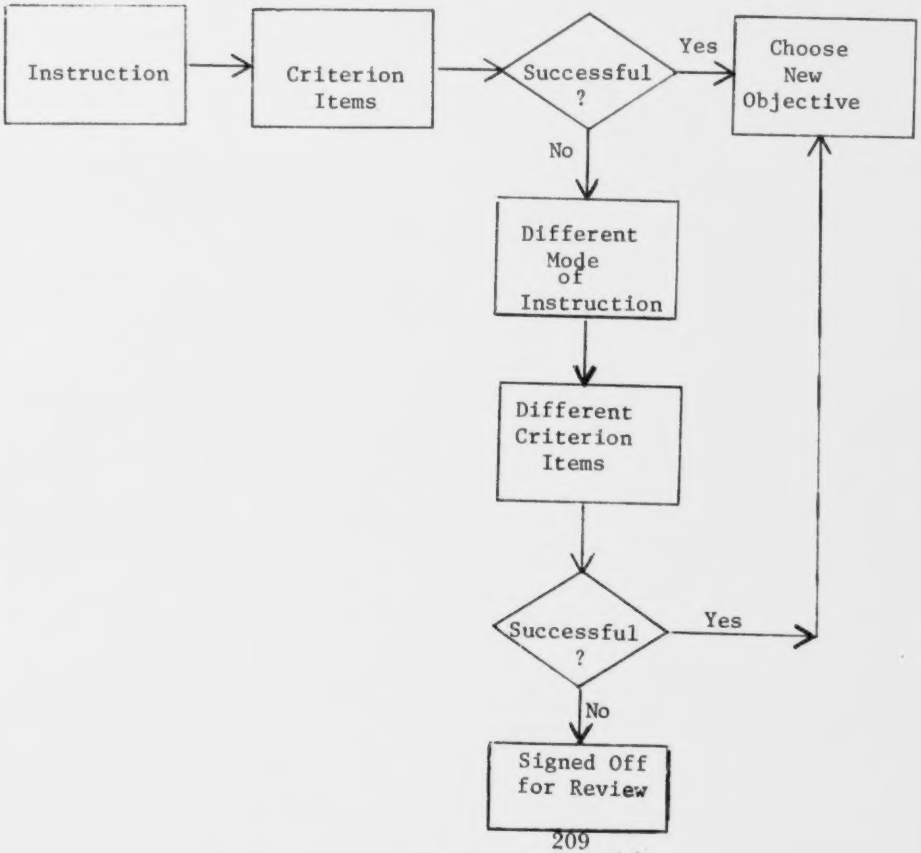
The sequence begins with an on-line entering behaviors test on factoring natural numbers and multiplying and dividing polynomials. Successful completion results in entry into the program. Following instruction and practice on any or all of the twenty identified enabling objectives, the student is presented with a ten item posttest to determine whether or not he has attained the terminal objectives.

FACTORING

PROGRAM INSTRUCTIONAL STRATEGY


Start
Entering Behaviors Test
Successful ?
Yes
No
Referred to Teacher
Student Choice of Objective for Study
Objective 9?
Yes
No
Posttest
End

SINGLE OBJECTIVE INSTRUCTIONAL STRATEGY


Instruction
Criterion Items
Successful ?
Yes
No
Choose New Objective
Different Mode of Instruction
Different Criterion Items
Successful ?
Yes
No
Signed Off for Review

Sample Section of Program

Point to the factors of:

$X^2 - 5X + 6$

A.	$(X - 6)\ (X + 1)$	$X^2 - 5X - 6$
B.	$(X - 2)\ (X - 3)$	$X^2 - 5X + 6$
C.	$(X + 6)\ (X - 1)$	$X^2 + 5X - 6$
D.	$(X + 2)\ (X - 3)$	$X^2 - X - 6$
E.	$(X - 6)\ (X - 1)$	$X^2 - 7X + 6$

P

The factors of a polynomial are those expressions which when multiplied together equal the polynomial.

$(X^2)\ (X + 1)$ are factors of $X^3 + X^2$
because $(X^2 \cdot X) + (X^2 \cdot 1) = X^3 + X^2$

S

Factor $-16\ a^2bc^3$

(1) Factor out -1 $\quad -1 \cdot 16 \cdot a^2bc^3$

(2) Factor integer $\quad -1 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot a^2bc^3$

(3) Factor variables

$-1 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot a \cdot a \cdot b \cdot c \cdot c \cdot c$

This is the complete factoring.

Comments

Pilot testing for this MIP was conducted with both Algebra I and Algebra II students at Einstein High School. A validation study is planned with similar populations during the fall semester of 1971.

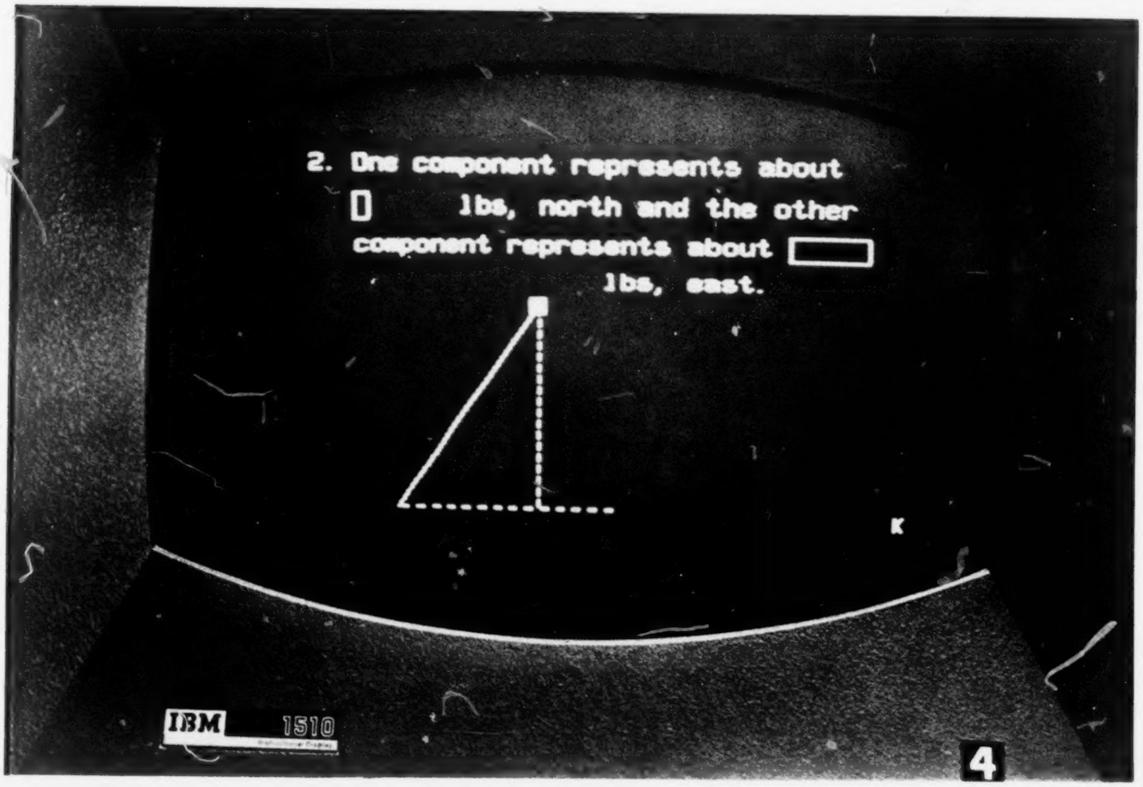
F. INTRODUCTION TO VECTORS

Assessment of Need

Introduction to Vectors like Dimensional Analysis was determined by responses gathered from approximately 850 questionnaries distributed to students in physics classes at Einstein and Walter Johnson High Schools. These physics students had no prior instruction on the use and theory of vectors nor any background in trigonometry. Thus this MIP is intended for students whose mathematical background does not include trigonometry.

Description of the Program

This is a tutorial program. The student interacts with the IBM 1510 Instructional Display, using the light pen and keyboard. Instructions for the terminal behavior employ the basic ideas of scale drawings and graphical representations. The program was authored by Catherine E. Morgan in the spring of 1969 and programmed by Anne Metzger, Project staff member, into COURSEWRITER II.



2. One component represents about ☐ lbs, north and the other component represents about ☐ lbs, east.

Terminal Objectives

1. Given a magnitude and a direction, the student constructs the corresponding vectors, using a ruler, and a 180° protractor.

2. Given a graphical representation of a vector, the student determines the magnitude and direction of the vector, using a ruler, graph paper, and a 180° protractor.

3. Given the coordinates of the two vectors, the student determines mathematically the coordinates of the resultant vector.

4. Given a graphical representation of two vectors, the student constructs the resultant vector, using a ruler, graph paper, and a 180° protractor.

Entering Behaviors

A. The student demonstrates a mastery of the use of a 180° protractor by measuring five given angles to the nearest degree.

B. The student names the coordinates of five points given in graphical representation.

C. The student using a ruler measures four line segments to the nearest 1/8 of an inch.

Enabling Objectives

AA Given sets of symbols that represent scalars and vectors, the student identifies those that represent scalars, and those that represent vectors.

AB Given a coordinate grid and the coordinates of two points, the student determines the location of the points on the grid.

AC Given the coordinates and graphical representations of two vectors and the graphical representation of their resultant vector, the student names the coordinates of the resultant vector.

AD Given the graphical representation of two vectors, the student names the coordinates of the resultant vector.

AE Given the coordinates of a vector, the student names the coordinates of the vector's inverse.

AF Given the graphical representation of two vectors, the student determines the coordinates of the sum of one vector and the inverse of the other vector.

AG Given the coordinates of two vectors, the student constructs the coordinates of the vector which represents their difference.

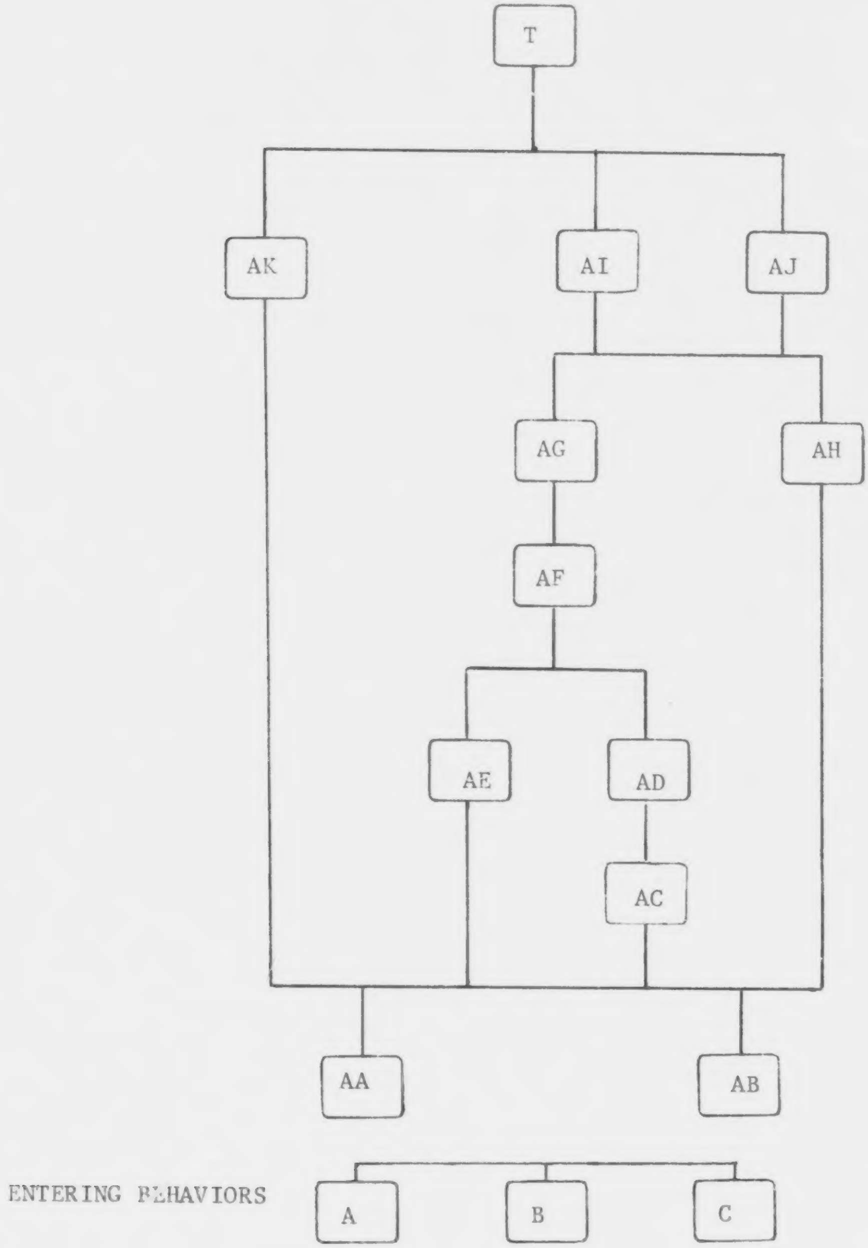
AH Given a graphical representation and the coordinates of a vector, the student names its magnitude and direction.

AI Given the magnitude and direction of a vector, the student, using a scale drawing, determines the magnitude and direction of two possible component vectors.

AJ Given a graphical representation and the coordinates of a resultant vector, the student, using the Pythagorean formula, determines the magnitude of the resultant vector.

AK Given a graphical representation and the coordinates of a resultant vector, the student determines its direction.

INTRODUCTION TO VECTORS - HIERARCHY


T
AK
AI
AJ
AG
AH
AF
AE
AD
AC
AA
AB
ENTERING BEHAVIORS
A
B
C

Pretest

Solve the following problems:

1. Using a scale of 1/4 inch = 10 kilometers, draw a vector whose magnitude is 55 kilometers and whose direction is 42° south of west.

2. Draw two possible components of the vector in problem 1 and name their magnitudes and directions.

3. Find the sum of vector A with coordinates of (7, –3) and vector B with coordinates of (–7, 4).

4. Draw vectors A and B from problem 3 and the resultant vector X.

5. Find the magnitude and direction of vector X in problem 4.

6. What are the coordinates of the vector Y which represents the difference between vector C with coordinates of (7, –2) and vector D with coordinates of (–1, –3)?

7. Draw vectors C and D from problem 6 and the vector Y which represents C – D.

8. Find the magnitude and direction of vector Y from problem 7.

Posttest

Solve the following problems and return to the terminal on the same program to check your answers and drawings.

1. Using a scale of 1/4 inch = 1 pound, draw a vector whose magnitude is 13 pounds and whose direction is 56° north of east.

2. Draw two possible components of the vector in problem 1 and name their magnitudes and directions.

3. Find the sum of vector A with coordinates of (6, –3) and vector B with coordinates of (–2, 4).

4. Draw vectors A and B from problem 3 and the resultant vector X.

5. Find the magnitude and direction of vector X in problem 4.

6. What are the coordinates of the vector Y which represents the difference between vector C with coordinates of (4, 0) and vector D with coordinates of (–2, 6)?

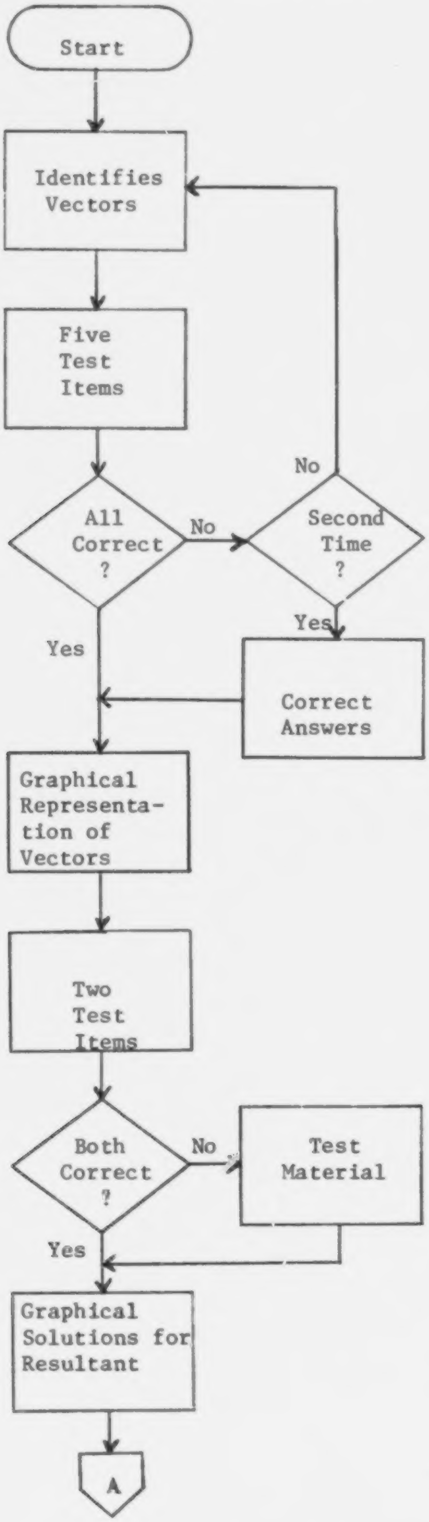
7. Draw vectors C and D from problem 6 and the vector Y which represents C – D.

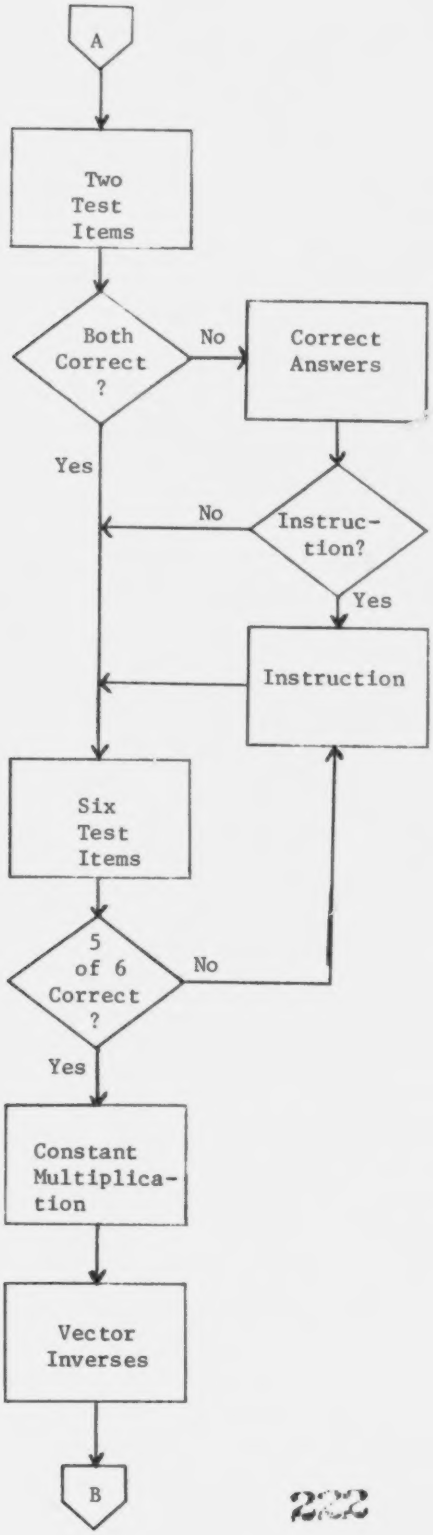
8. Find the magnitude and direction of vector Y from problem 7.

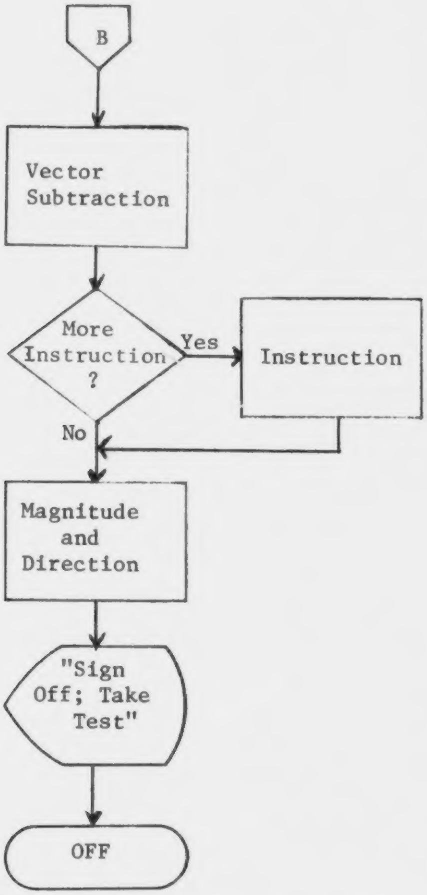
Mode of Presentation

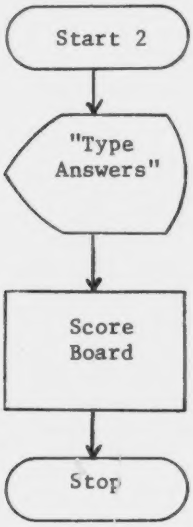
Using scale drawings and graphical representations, the student receives instruction in constructing vectors and identifying their magnitude and direction. He utilizes the 1510 Instructional Display with light pen as he progresses through this tutorial unit.

INTRODUCTION TO VECTORS - INSTRUCTIONAL STRATEGY

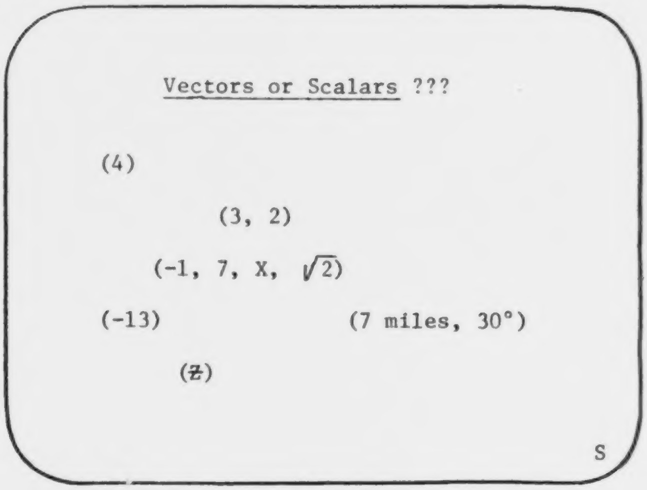

Start
Identifies Vectors
Five Test Items
All Correct ?
No
Second Time ?
No
Yes
Correct Answers
Yes
Graphical Representation of Vectors
Two Test Items
Both Correct ?
No
Test Material
Yes
Graphical Solutions for Resultant
A


A
Two Test Items
Both Correct ?
No
Correct Answers
Yes
No
Instruction?
Yes
Instruction
Six Test Items
5 of 6 Correct ?
No
Yes
Constant Multiplication
Vector Inverses
B


B
Vector Subtraction
More Instruction ?
Yes
Instruction
No
Magnitude and Direction
"Sign Off; Take Test"
OFF


Start 2
"Type Answers"
Score Board
Stop

Sample Section of Program



Vectors or Scalars ???

(4)

(3, 2)

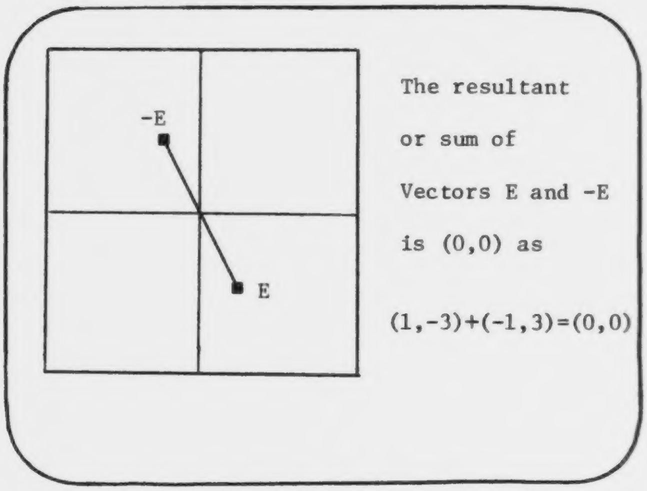
(-1, 7, X, $\sqrt{2}$)

(-13)

(7 miles, 30°)

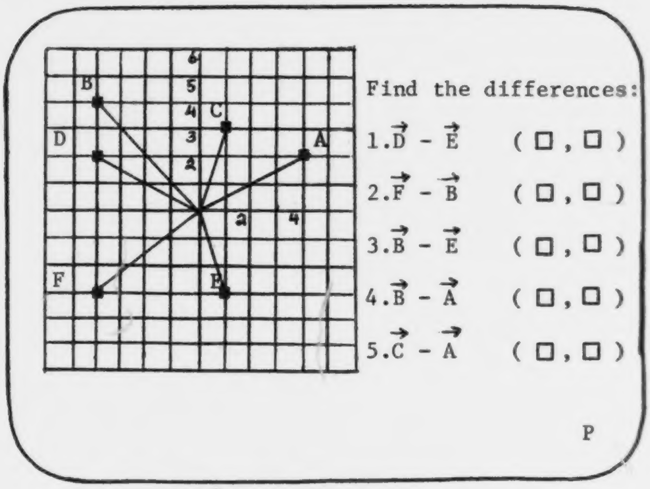
(Z)

S



The resultant or sum of Vectors E and -E is (0,0) as

(1,-3)+(-1,3)=(0,0)



Find the differences:

1.$\vec{D} - \vec{E}$ (☐ , ☐)

2.$\vec{F} - \vec{B}$ (☐ , ☐)

3.$\vec{B} - \vec{E}$ (☐ , ☐)

4.$\vec{B} - \vec{A}$ (☐ , ☐)

5.$\vec{C} - \vec{A}$ (☐ , ☐)

P

Comments

Although this MIP was intended originally for those students who would be taking physics without previous instruction in vectors, it has also been used as an introduction for mathematics students in Advanced Algebra and Trigonometry classes. It is a short unit that employs the basic ideas of scale drawings and graphical representations.

g. GEOMETRY TESTING

Assessment of Need

In the summer of 1968, several Montgomery County mathematics teachers, participating in a workshop, began developing behavioral objectives, hierarchies, and criterion test questions and gathering reference materials for a projected ten-unit geometry course. Subsequent geometry workshops were devoted to continued writing and revising of these materials throughout the following school years and summers until their completion in June, 1970. Three CAI supporting teachers participated in these activities and are currently working on a project in which the assessment tasks, diagnostic elements, and prescriptive ingredients from the geometry curriculum workshops are re-examined, revised, and coded for use on the 1500 Instructional System. During the spring of 1969, geometry materials for the first four units were coded.

Description of the Program

The computer is readily adapted to the technique of testing; and, as a result, considerable use has been made of this technique in the geometry program. Over a two-year period, test items for five units were written, revised, and coded into COURSEWRITER II. They were used initially in a 1970 summer school session at Einstein High School. These units were:

I Introduction to Logic

II Geometry as a Mathematical System

III Methods of Proof

IV Parallels and Perpendiculars

V Congruence

The geometry materials are used in a computer-managed instruction mode with diagnosis and testing occurring at computer terminals. All instruction is off-line and does not involve the computer; students are provided individualized instruction through personal interaction with the teacher and activity sheets keyed to at least three textbooks.

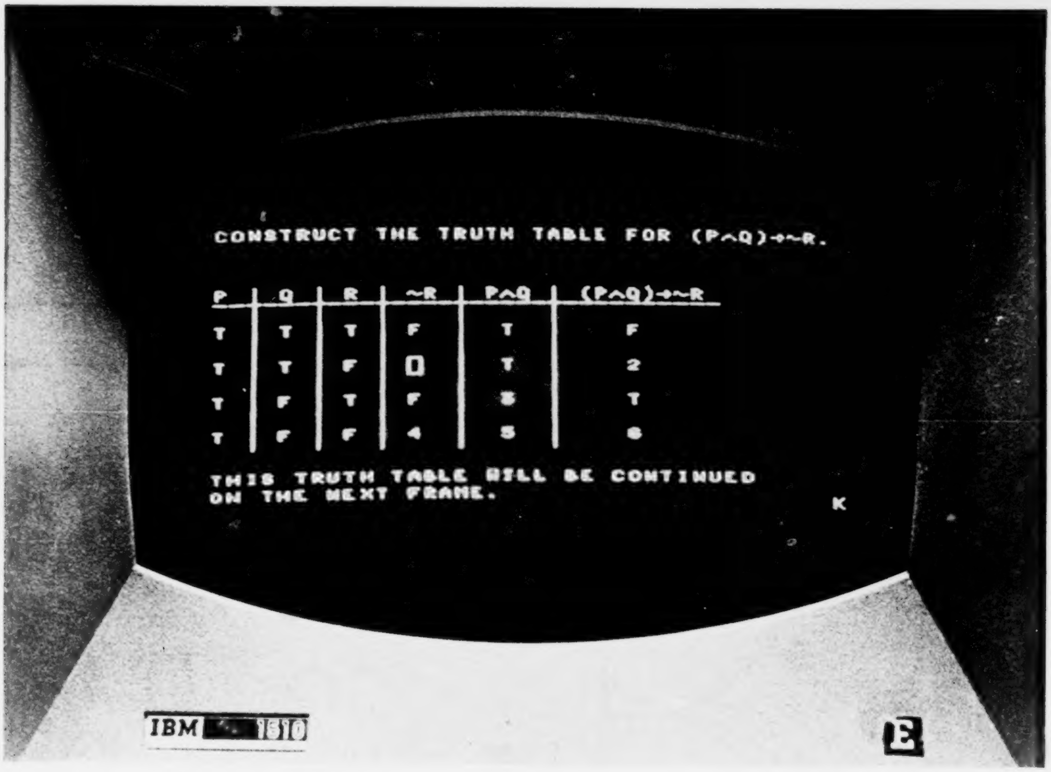
In January, 1971, the first semester geometry examination was taken at computer terminals; each student received an individualized examination consisting of randomly generated questions based on the objectives the student had attained to that date.

Mode of Presentation

As the student enters this CMI geometry course, he may follow this pattern:

1. Takes diagnostic test on the computer terminal
2. Receives score and prescribed beginning behavioral objective
3. Returns to classroom to study materials related to specified objective
4. Completes study and returns to computer terminals for criterion test on objective
5. Continues this process for the next objective if predetermined criteria are attained
6. Restudies material and/or consults teacher if predetermined criteria are not attained
7. Returns to terminal for alternate criterion test
8. Repeats step five or steps six and seven

Out of this type of environment the definition of Computer-Managed Instruction (CMI) emerged. The computer is used for testing, evaluation, diagnosis, and prescription, thus managing the instructional atmosphere.

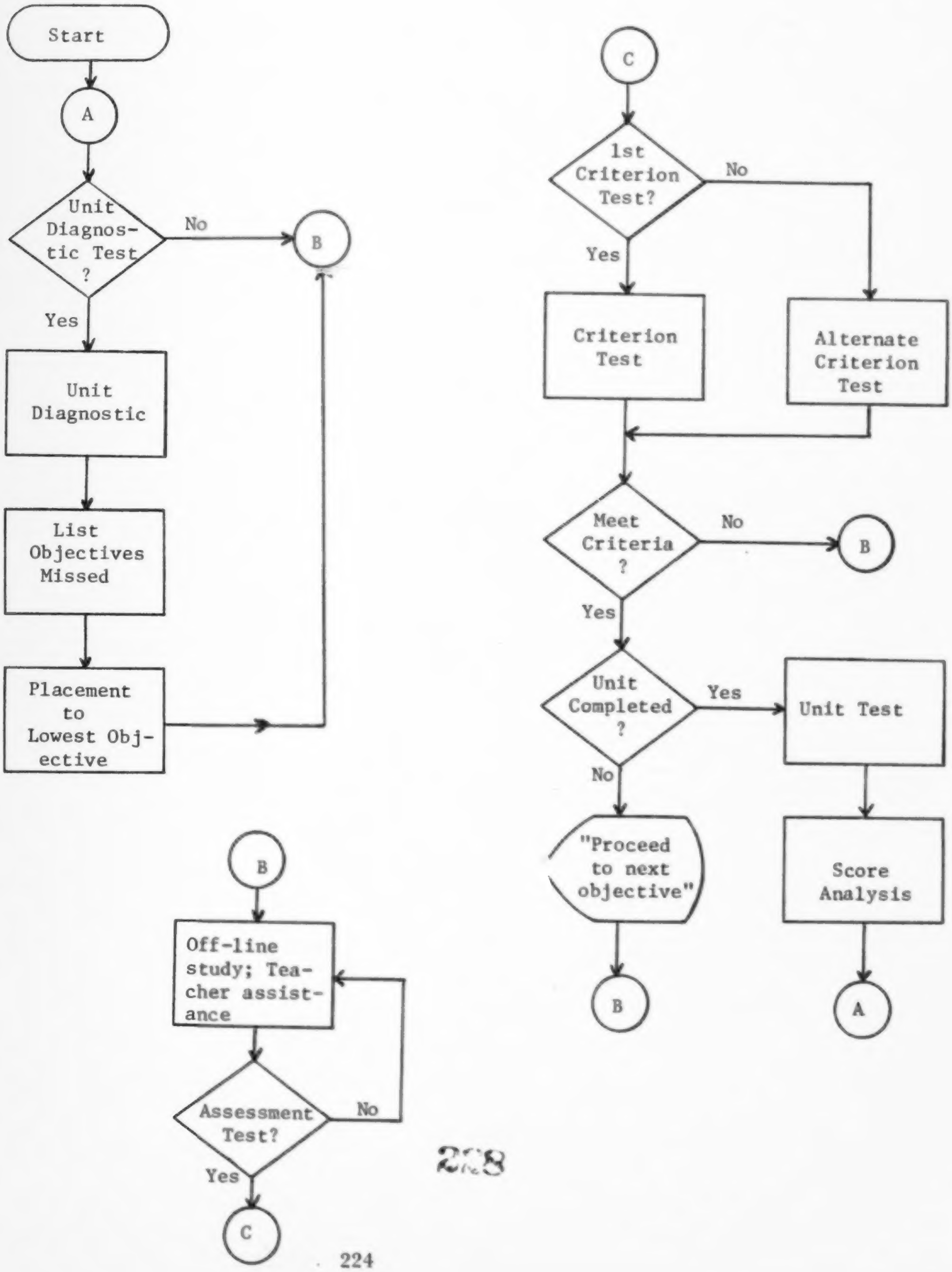


```
CONSTRUCT THE TRUTH TABLE FOR (P^Q)→~R.

P | Q | R | ~R | P^Q | (P^Q)→~R
T | T | T | F  |  T  |    F
T | T | F | □  |  T  |    2
T | F | T | F  |  3  |    T
T | F | F | 4  |  5  |    6

THIS TRUTH TABLE WILL BE CONTINUED
ON THE NEXT FRAME.                        K
```

GEOMETRY TESTING - INSTRUCTIONAL STRATEGY


Start
A
Unit Diagnostic Test ?
No
B
Yes
Unit Diagnostic
List Objectives Missed
Placement to Lowest Objective
B
Off-line study; Teacher assistance
Assessment Test?
No
Yes
C
C
1st Criterion Test?
No
Yes
Criterion Test
Alternate Criterion Test
Meet Criteria ?
No
B
Yes
Unit Completed ?
Yes
Unit Test
No
"Proceed to next objective"
Score Analysis
B
A

Comments

The trial use of this systems approach elicited such enthusiasm from both students and teacher that CMI geometry was incorporated into the mathematics program for three classes in September of 1970. The course was taught by the same teacher.

During the 1971-72 academic year, the remaining five geometry units will be coded into COURSEWRITER II, making the entire CMI geometry curriculum available. These units include:

VI Similarity

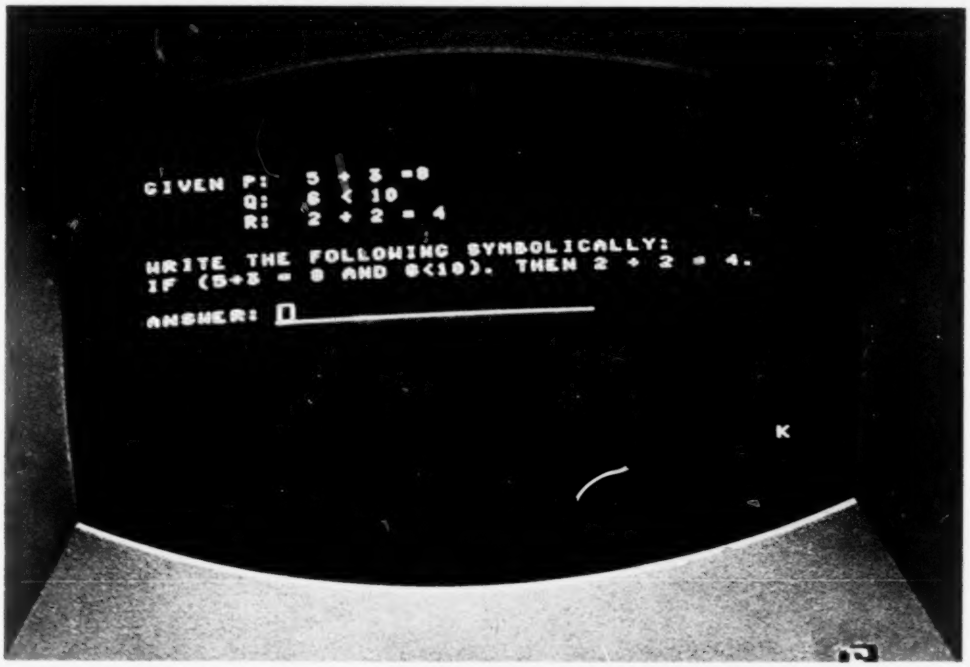
VII Circles

VIII Constructions and Loci

IX Areas and/or Volumes of Plane and Solid Figures

X Selected Problems and Practical Applications

As this document goes to press, validation and evaluation are being scheduled for the ten completed units.



```
GIVEN P:  5 + 3 =8
      Q:  6 < 10
      R:  2 + 2 = 4

WRITE THE FOLLOWING SYMBOLICALLY:
IF (5+3 = 8 AND 6<10). THEN 2 + 2 = 4.

ANSWER: ▯___________________
```

h. PROBLEM SOLVING

Assessment of Need

Reading and interpreting simple situations and translating these situations into algebraic equations with the variable identified as to its representation are essential skills in elementary algebra. Thus to assist the student in mastery of these basic skills, Problem Solving – Algebra I was written.

Description of the Program

Using the 1510 Instructional Display with light pen, the student exercises control of his individual path through this program. After instruction on a given sample problem, he is provided with a list of 12 other problems. For each of these, he may choose to identify the elements, draw a diagram, construct the equation, and/or request an explanation on how to write the equation. The amount of time he spends on each problem and the number of times he views a single problem are once again his choice. When he feels confident enough to begin writing equations for simple problems, he then takes a posttest. The posttest is formed by selecting, randomly, five problems from a list of ten. For each problem, he identifies the statement that represents the variable and the respective equation. A score of four or five correct is considered satisfactory.

This tutorial unit was designed and authored by Catherine E. Morgan, teacher specialist in curriculum, in the spring of 1970. William G. Swisher programmed the modular instructional package into COURSEWRITER II.

Terminal Objective

Given five verbal problems, a list of statements representing variable assignments, and a list of equations utilizing the variable assignments, the student identifies the variable assignment and equation which represent the solution of at least four problems.

Objectives

The enabling objectives for this program are student determined, based upon individual needs. The four areas identified as essential processes for reaching the terminal objective are:

1. Identification of elements
2. Diagramming the given material and/or circumstances
3. Interpreting the problem
4. Writing algebraic equations

The student may receive assistance in any or all of these areas for each of the 12 practice-oriented problems.

Posttest Item

The following is one of ten items a student may receive at the completion of this program.

If an item costs $1.95, how much will 30 of these same items cost?

Identify the variable assignment which should be used:

a. Let x = Number of dollars total

b. Let x = Number of cents total

c. Let x = Number of dollars one item costs

Identify the equation which should be used to solve the problem:

a. $1.95 \cdot x = 30$

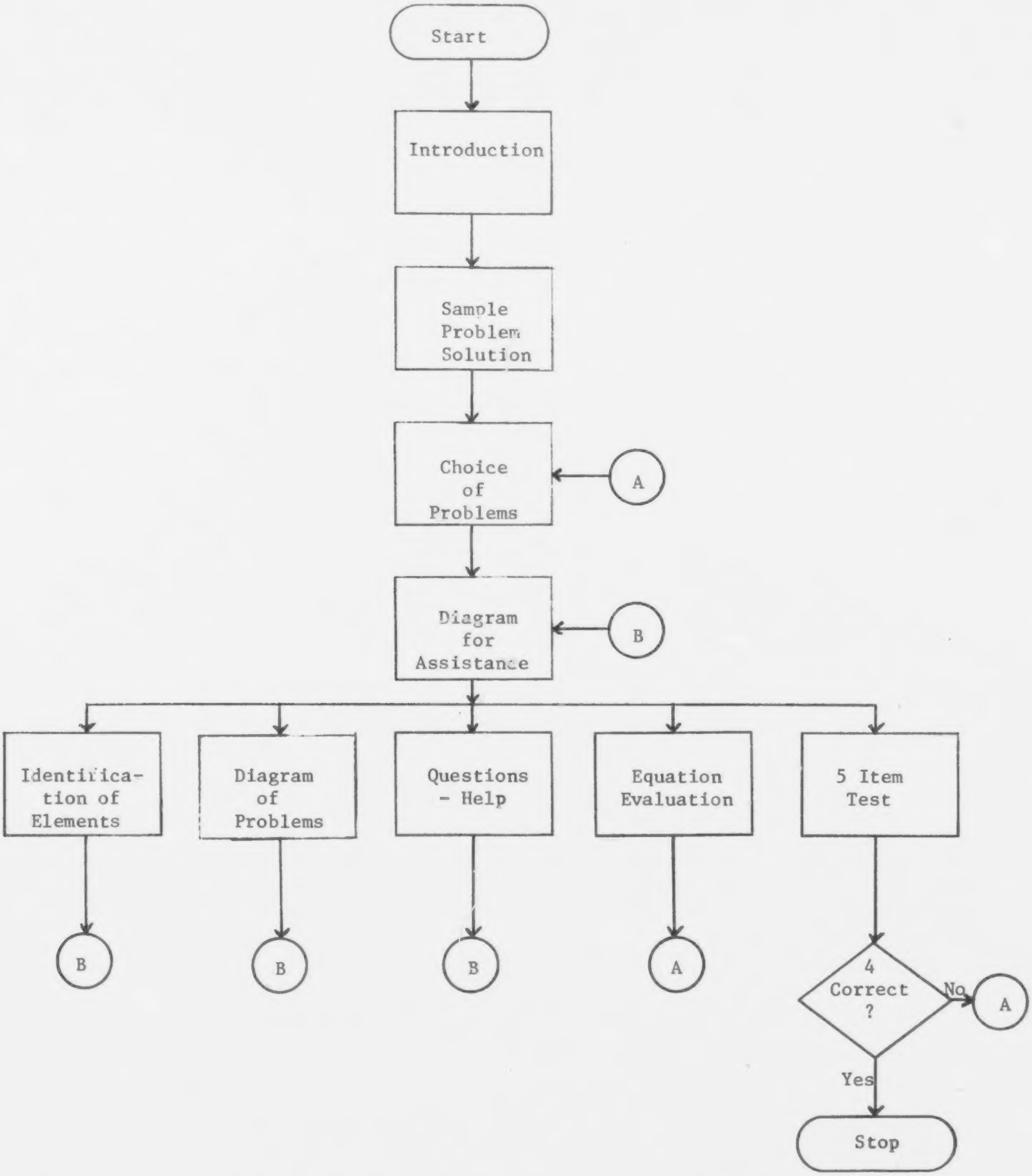
b. $x = 30 \cdot 1.95$

c. $30 \cdot x = 1.95$

Mode of Presentation

This MIP is primarily tutorial in nature, making use of inquiry techniques and student-controlled strategy. The individual student has the opportunity to investigate his ability to read, interpret, and design solutions for simple verbal problems. On line, the student interacts with the computer, using the light pen and keyboard of the IBM 1510 Instructional Display.

PROBLEM SOLVING - INSTRUCTIONAL STRATEGY


Start
Introduction
Sample Problem Solution
Choice of Problems
A
Diagram for Assistance
B
Identification of Elements
Diagram of Problems
Questions - Help
Equation Evaluation
5 Item Test
B
B
B
A
4 Correct ?
No
A
Yes
Stop

Problems for Use with Program

1. Mary's allowance is five times as large as her younger sister's. Mary receives $3.00 a week. What is her sister's weekly allowance?

2. Jo needs four yards of material to make a dress and jacket. The cost for each yard of material is $3.50. What will the cost of material be?

3. What is the distance around a rectangular piece of land 58 feet long and 14 feet wide?

4. If a number is tripled, its value will be 51. What is the number?

5. A schoolroom is three feet longer than it is wide. Its perimeter is 112 feet. What is its length and its width?

6. Fifty paperback books were sold, some at fifty cents and the rest at sixty cents, during a one-week period. If $18.40 in book sales were made, how many books at each price were sold?

7. In a high school, 180 students are taking two foreign languages, French and German. The number of German students is one-third of those taking French. How many students are taking each language?

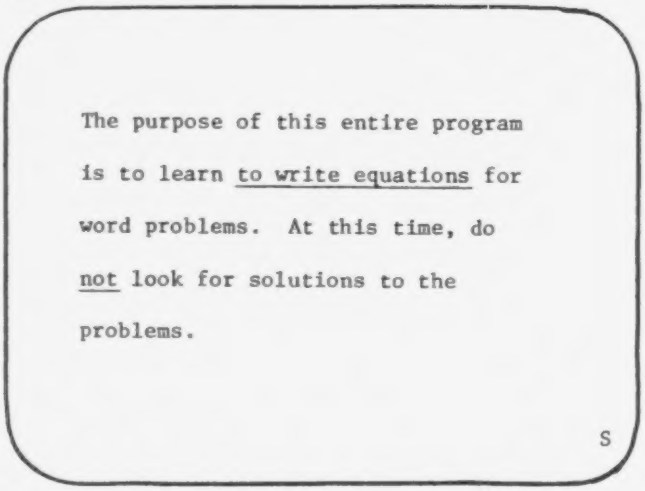
8. A jet traveling east at 650 miles an hour and a plane traveling west at 370 miles an hour leave New York at the same time. In how many hours will the planes be 3570 miles apart?

9. Mr. Jones travels 796 miles from Chicago to a small town in Pennsylvania. The first part of the trip is made by train traveling 55 miles an hour and the second part by truck which only averages 20 miles an hour. If he travled one hour longer by truck than by train, how many hours will the trip take?

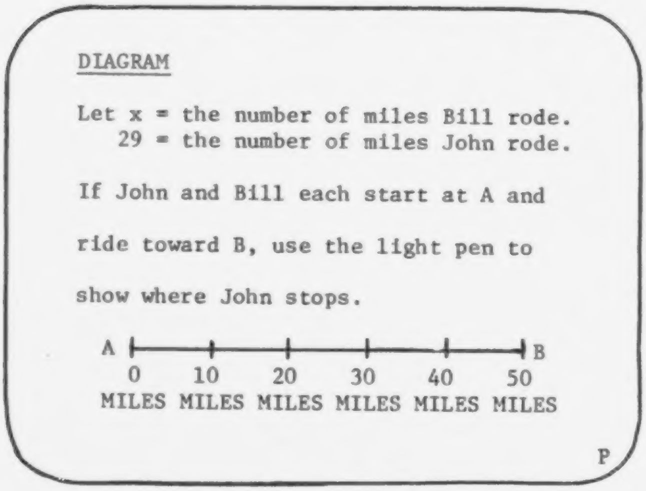
10. How many pounds of ninety-eight cents a pound coffee must be blended with some eighty-five cents a pound coffee to make 20 pounds of coffee which will sell at eighty-nine cents a pound?

11. If three consecutive odd numbers have a sum of 177, what is the smallest number?

12. Jody rides her bicycle from home to the library; but when she wishes to return home, she finds she has a flat tire. Leaving her bike, she walks home. If the entire trip takes one hour and fifteen minutes and she walks at the rate of three miles an hour and bikes at the rate of six miles an hour, how long did it take her to walk home?



The purpose of this entire program is to learn to write equations for word problems. At this time, do not look for solutions to the problems.

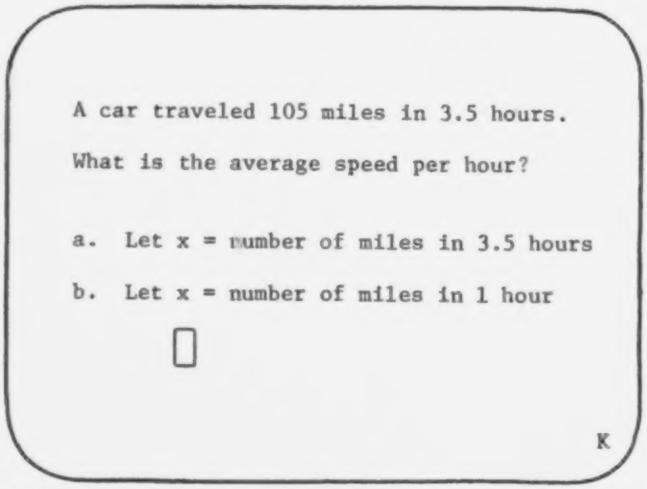


DIAGRAM

Let x = the number of miles Bill rode.
29 = the number of miles John rode.

If John and Bill each start at A and ride toward B, use the light pen to show where John stops.

A
B
0 MILES
10 MILES
20 MILES
30 MILES
40 MILES
50 MILES
P



A car traveled 105 miles in 3.5 hours. What is the average speed per hour?

a. Let x = number of miles in 3.5 hours

b. Let x = number of miles in 1 hour

☐

Comments

This program was used with three Algebra I classes during the 1970-71 school year. When used for remediation, its inquiry nature allowed student self-diagnosis of difficulties encountered with problem-solving skills.

i. TRIGONOMETRIC SOLUTIONS OF RIGHT TRIANGLES

Assessment of Need

High school students enrolled in basic mathematics courses usually do not receive instruction in trigonometric concepts. Thus, the purpose of this modular instructional package is to introduce those students to the sine, cosine, and tangent functions and their use in computing the measures of sides and angles of right triangles.

Description of the Program

Trigonometric Solutions of Right Triangles is a tutorial unit with many opportunities for the student to review material and receive remediation. An off-line pretest is available, and a posttest is included in the CAI program. Using the 1510 Instructional Display with light pen, the student progresses at his own pace through the trig unit. This unit was written by Catherine Morgan, Thomas E. Robinson, and Eleanor Lautenschlager, and programmed in COURSEWRITER II by Chris Eshleman.

Terminal Objective

Given two right triangles:

1. One with measures of one acute angle and one side
2. The other with measures of two sides

The student names the measures of the other side(s) and angle(s).

Entering Behaviors

A. Given five right triangles, the student identifies the right angle in each triangle.

B. Given four simple proportions (i.e., 4:5 = x:15), the student solves them algebraically.

Enabling Objectives

1. Given a set of triangles, the student identifies a right triangle as the one with a right angle.

2. Given a triangle, the student names it angles by the lettered vertices.

3. Given the measure of one acute angle of a right triangle, the student names the measure of the other acute angle.

4a. Given a right triangle, the student identifies the hypotenuse.

4b. Given a right triangle, the student identifies the legs.

4c. Given a right triangle, the student identifies the angle(s) which is (are) opposite to each leg(s).

4d. Given a right triangle, the student names the acute angles.

4e. Given an acute angle in a right triangle, the student labels the sides opposite to or adjacent to that angle.

5. Given a list of ratios describing the sides of a right triangle, the student matches each with the respective trig function (tan, cos, sin).

6a. Given a right triangle and measures of the three sides, the student constructs the three trig functions for each of the acute angles.

6b. Given the ratios of two sides, the student identifies which trig function is described by that ratio.

7a. Given a right triangle and measures of three sides and the acute angles, the student writes the proportions for the three trig functions.

7b. Given a right triangle with measures of one side and an acute angle, the student writes the proportion for the trig function, using a variable where needed.

8. Given a table of trigonometric ratios, the student writes the sine, cosine, or tangent for any integral angles between 0 and 90 degrees.

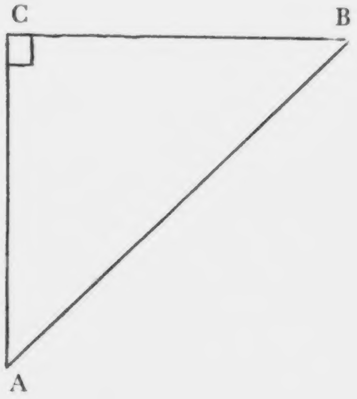
9. Given a number and the trig function it represents, the student names the angle to the nearest degree.

10. Given a right trangle and the measures of two sides, the student names the measures of the acute angles.

11. Given a right triangle and the measures of one side and an acute angle, the student names the measures of the other two sides.

Pretest – Posttest

A sample question from the posttest follows:



BC = 9.8 cm

AC = 9.1 cm

To the nearest degree

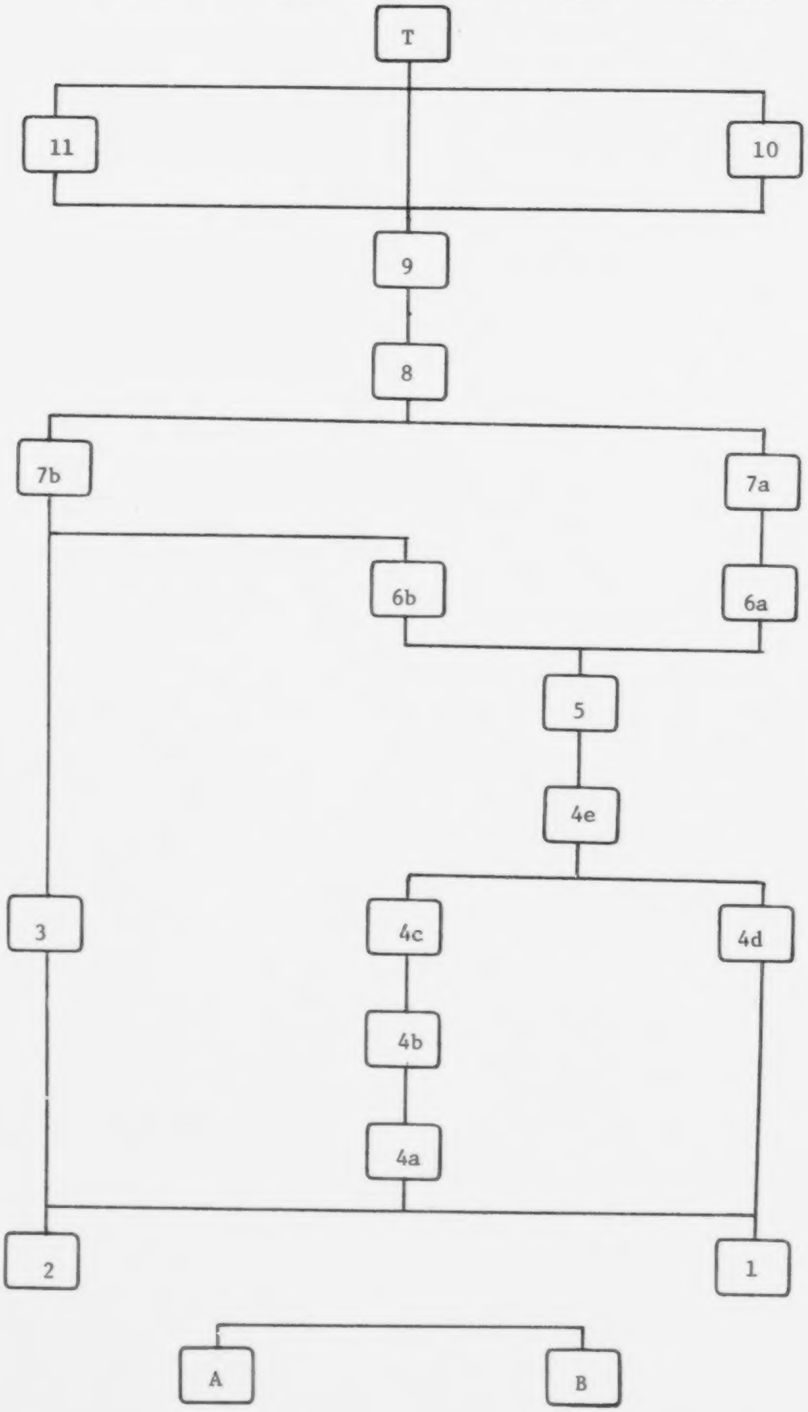
$< A = ?$

$< B = ?$

To the nearest tenth

$\overline{AB} = ?$

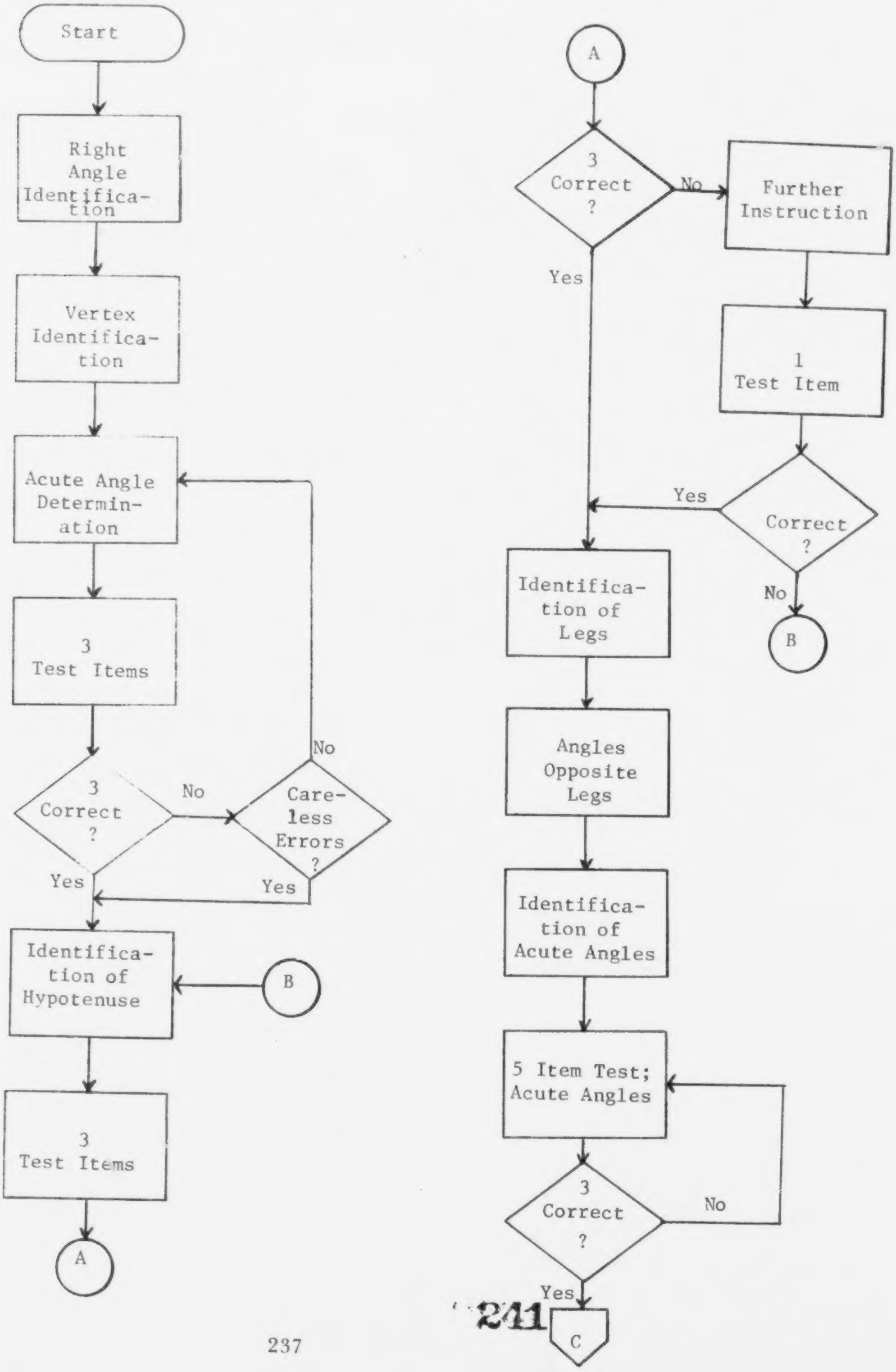
TRIGONOMETRIC SOLUTIONS OF RIGHT TRIANGLES - HIERARCHY

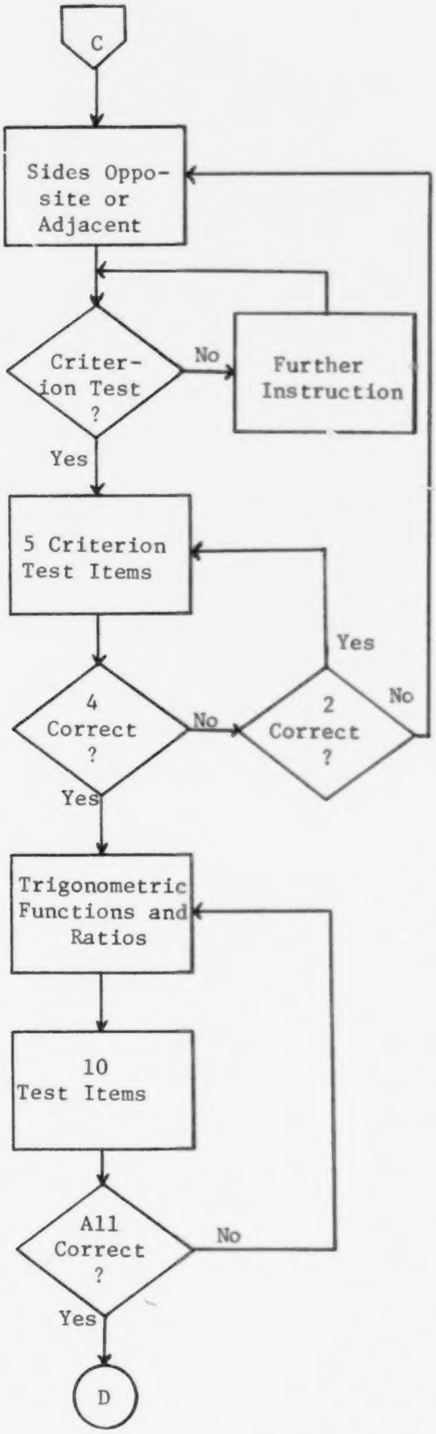

T
11
10
9
8
7b
7a
6b
6a
5
4e
3
4c
4d
4b
4a
2
1
A
B

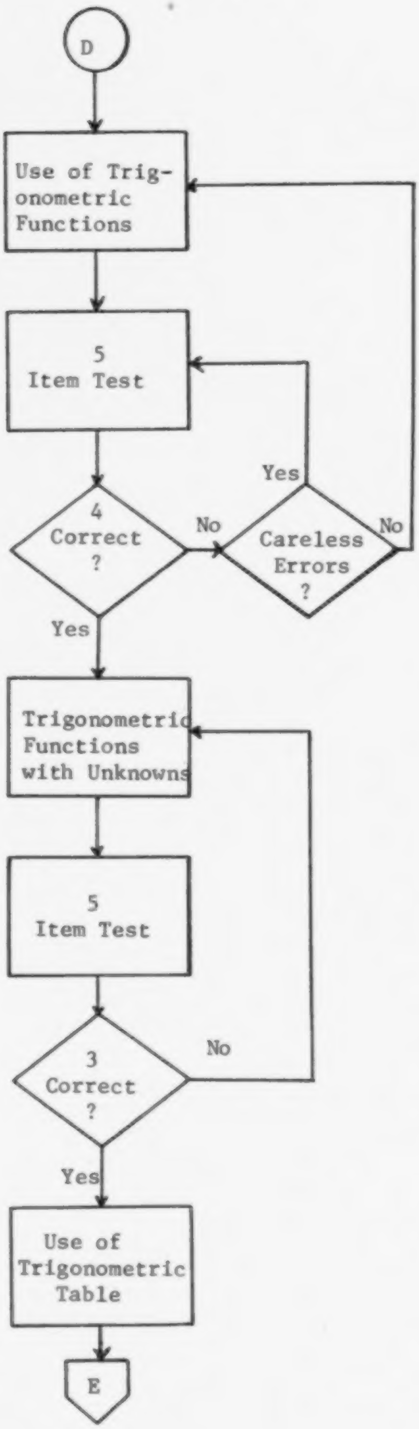
Mode of Presentation

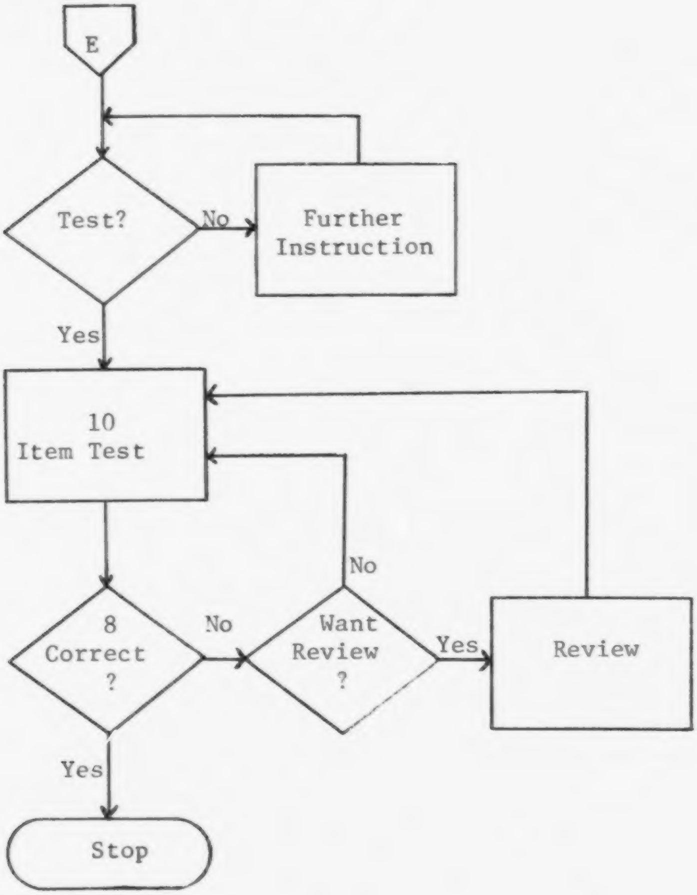
Trigonometric Solutions of Right Triangles is a tutorial unit that allows the student ample opportunities to choose various paths through the program, which may include separate review units. This MIP employs the 1510 Instructional Display with light pen, in addition to a four-place trig table, which must be made available for the student's use.

TRIGONOMETRIC SOLUTIONS OF RIGHT TRIANGLES - INSTRUCTIONAL STRATEGY

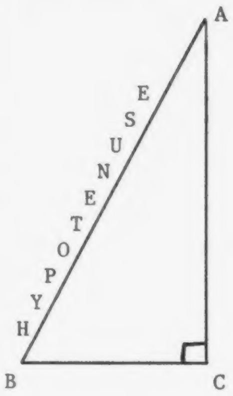

Start
Right Angle Identification
Vertex Identification
Acute Angle Determination
3 Test Items
3 Correct ?
No
Careless Errors ?
No
Yes
Yes
Identification of Hypotenuse
B
3 Test Items
A
A
3 Correct ?
No
Further Instruction
1 Test Item
Correct ?
Yes
No
B
Yes
Identification of Legs
Angles Opposite Legs
Identification of Acute Angles
5 Item Test; Acute Angles
3 Correct ?
No
Yes
C


C
Sides Opposite or Adjacent
Criterion Test ?
No
Further Instruction
Yes
5 Criterion Test Items
Yes
4 Correct ?
No
2 Correct ?
No
Yes
Trigonometric Functions and Ratios
10 Test Items
All Correct ?
No
Yes
D


D
Use of Trigonometric Functions
5 Item Test
Yes
4 Correct ?
No
Careless Errors ?
No
Yes
Trigonometric Functions with Unknowns
5 Item Test
3 Correct ?
No
Yes
Use of Trigonometric Table
E


E
Test?
No
Further Instruction
Yes
10 Item Test
8 Correct ?
No
Want Review ?
Yes
Review
No
Yes
Stop

Sample Section of Program



The longest side of a right triangle is called the HYPOTENUSE.

"HY-POT-E-NUSE"

It is also said to be the side opposite the right angle.

S

There are 3 Trigonometric Ratios for every acute angle in a right △ .

The 3 ratios are:

1. Tangent
2. Sine
3. Cosine

S

ANGLE	SINE	COSINE	TANGENT

To find the sin 30° read down the angle column until you come to 30°. Notice in the column labeled sine, that the sin 30° is .5000. Also notice that the cos is .8660 and the tan is .5774.

S

Comments

Author debugging for such an extensive package required more time than had been anticipated. Consequently, during the summer of 1971 this process will be continued with an expected student pilot-testing scheduled for the academic year 1971-1972.

j. PERIMETER-AREA-INVESTIGATION

Assessment of Need

A survey of high school students indicated that many experienced difficulty with relatively simple concepts of areas and perimeters of common place figures. Thus the Perimeter-Area-Investigation package was written.

Description of the Program

Five short APL programs are combined to constitute this unit on perimeter-area-investigation. The student, interacting with the 1510 Instructional Display Unit, enters numbers which represent linear measurements of plane figures. The computer then takes these measurements and, for a given plane figure, calculates the perimeter and area. When the student receives these results, his task is to identify the plane figure that has been used for these calculations. Once identification has been determined, he is asked to write an APL program which calculates the area and perimeter of any like plane figure.

This investigatory package was designed, authored, and coded into A PROGRAMMING LANGUAGE by Catherine E. Morgan.

Terminal Objective

Following the use of the computer units, the student develops coded APL programs for the area and perimeter of a rectangle, triangle, circle and parallelogram.

Comments

Basic to completing the second objective in this unit is a brief introduction to writing short APL programs.

Student Booklet

Perimeter

Area

Investigation

Resting in the computer's brain are five programs which can be used to find the perimeters and areas of some common plane figures.

Resting in your brain may be ten formulas which can be matched to the five programs buried in the computer.

Your job will be to match the programs with your knowledge by:

1. Identifying the plane figures whose areas and perimeters can be obtained from each program
2. Writing an APL program which will find the area and perimeter for each of the above

Suggestions for your investigation:

Suppose there is a program called *A*, and you call up this program by typing *A* on the keyboard.
Printed on the CRT is a message which states: "ENTER A NUMBER OF UNITS"
followed by ☐ :
The program expects you to enter any number that you wish. You might then type ☐ : 10
Printed on the screen would be
"ONE RESULT IS 40 UNITS"
And "THE OTHER RESULT IS 100 SQUARE UNITS"

Your might suspect that these results are the perimeter and area of a square with a side whose length is 10 units. To be certain you might try some other numbers for the length of the side.

For each number that you wish to enter, you will have to type *A* and enter the desired number. You will then receive the two results for your new number. When you are convinced that you know what computations the program is making, you will be ready to write a similar program.

To write the program, you may need to refer to your APL manual. Call the program A. You may use any letters within the program to represent perimeter, area, and side. However, since the name of the program is A, you must choose a letter other than A for area. A sample program is as follows:

```
▼ A

[1] P<– 4 x S      (the perimeter of the square is four times the length of a side)

[2] T< – S * 2     (the area of the square is the length of the side times itself,
                    which could have also been written T = S x S)

[3] ▼
```

If your program A and the computer's program *A* give the same results when the same numbers are used for the length of a side of the square, then the assumption is that they perform the same function.

To test your program, first type S → N (any number you choose), enter this by pressing the "RETURN" key, then type A, return, type P, return, and the answer for the perimeter will be computed and displayed on the CRT. Then Type T, return, and the area will be computed and displayed on the CRT. Repeat this process for several possible numbers, and you will know whether your program does compute the area and perimeter of any square.

The programs you will be investigating will have the following names:

Q *W* *L* *D* *G*

To use these programs, sign on with your APL number, then type the following:

```
)PCOPY 987654 PROGRAM NAME
```

The results should be entered on the INVESTIGATION SHEETS.

Computer Program Print-Out

```
  ∇D̲[⎕]∇
∇D̲;A;B;C;D;E
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS'
[5]  B←⎕
[6]  'ENTER A THIRD NUMBER OF UNITS'
[7]  C←⎕
[8]  'ENTER A FOURTH NUMBER OF UNITS'
[9]  D←⎕
[10]  'ENTER A FIFTH NUMBER OF UNITS'
[11]  'WHICH IS SMALLER THAN EITHER OF'
[12]  'THE LAST TWO YOU ENTERED'
[13]  E←⎕
[14]  'ONE RESULT IS ';A+B+C+D;' UNITS'
[15]  'THE OTHER RESULT IS ';.5×E×A+C;' SQUARE UNITS'
 ∇
```

```
  ∇G̲[⎕]∇
∇G̲;A;B;C
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS'
[5]  B←⎕
[6]  'ENTER A THIRD NUMBER OF UNITS'
[7]  'WHICH IS LESS THAN LAST NUMBER'
[8]  'YOU ENTERED'
[9]  C←⎕
[10]  'ONE RESULT IS  ';2×A+B; ' UNITS'
[11]  'THE OTHER RESULT IS ';A×C;' SQUARE UNITS.'
 ∇
```

```
  ∇Q[⎕]∇
∇Q;A;B
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS.'
[5]  B←⎕
[6]  'ONE RESULT IS ';A×B;' SQUARE UNITS'
[7]  'THE OTHER RESULT IS ';2×A+B;' UNITS'
 ∇
```

```
  ∇W[⎕]∇
∇W;A;B;C
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS'
[5]  B←⎕
[6]  'ENTER A THIRD NUMBER OF UNITS'
[7]  'WHICH IS LESS THAN THE SUM OF'
[8]  'THE LAST TWO NUMBERS.'
[9]  C←⎕
[10]  'ENTER A FOURTH NUMBER OF UNITS'
[11]  'WHICH IS LESS THAN EITHER OF '
[12]  'THE FIRST TWO NUMBERS YOU ENTERED.'
[13]  D←⎕
[14]  'ONE RESULT IS ';A+B+C;' UNITS'
[15]  'THE OTHER RESULT IS ';.5×B×D;' SQUARE UNITS'
 ∇
```

```
  ∇L[⎕]∇
∇L;A
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ONE RESULT IS ';3.1416×A*2;' SQUARE UNITS'
[5]  'THE OTHER RESULT IS ';2×3.1416×A;' UNITS'
 ∇
```

Sample Student Interaction

```
  D
ENTER A NUMBER OF UNITS
⎕:
  6.5
ENTER ANOTHER NUMBER OF UNITS
⎕:
  3.9
ENTER A THIRD NUMBER OF UNITS
⎕:
  7.1
ENTER A FOURTH NUMBER OF UNITS
⎕:
  5
ENTER A FIFTH NUMBER OF UNITS
WHICH IS SMALLER THAN EITHER OF
THE LAST TWO YOU ENTERED
⎕:
  2
ONE RESULT IS  22.5 UNITS
THE OTHER RESULT IS  13.6 SQUARE UNITS
```

```
  G
ENTER A NUMBER OF UNITS
⎕:
  6
ENTER ANOTHER NUMBER OF UNITS
⎕:
  16
ENTER A THIRD NUMBER OF UNITS
WHICH IS LESS THAN LAST NUMBER
YOU ENTERED
⎕:
  10
ONE RESULT IS  44 UNITS
THE OTHER RESULT IS 60 SQUARE UNITS.
```

```
  Q
ENTER A NUMBER OF UNITS
⎕:
  4
ENTER ANOTHER NUMBER OF UNITS.
⎕:
  6
ONE RESULT IS 24 SQUARE UNITS
THE OTHER RESULT IS 20 UNITS
```

```
  W
ENTER A NUMBER OF UNITS
⎕:
  10
ENTER ANOTHER NUMBER OF UNITS
⎕:
  8
ENTER A THIRD NUMBER OF UNITS
WHICH IS LESS THAN THE SUM OF
THE LAST TWO NUMBERS.
⎕:
  7
ENTER A FOURTH NUMBER OF UNITS
WHICH IS LESS THAN EITHER OF
THE FIRST TWO NUMBERS YOU ENTERED.
⎕:
  6
ONE RESULT IS 25 UNITS
THE OTHER RESULT IS 24 SQUARE UNITS
```

```
  L
ENTER A NUMBER OF UNITS
⎕:
  5
ONE RESULT IS  78.54 SQUARE UNITS
THE OTHER RESULT IS  31.416 UNITS
```

k. VOLUME-AREA-INVESTIGATION

Assessment of Need

A survey to determine the mathematical needs of high school students indicated that a high percentage experienced difficulty in volumes and surface areas of common three-dimensional figures. With this need in mind, the author wrote and designed the Volume-Area-Investigation program.

Description of the Program

Similar in format to Perimeter-Area-Investigation, Volume-Area-Investigation begins by asking the student to enter numbers representing linear measurements. The calculations that are performed and returned to the student now represent the lateral area, surface area, and volume of some three-dimensional figure. The student's task is to identify the figure that has been used to produce these results. After identification has been determined, he is asked to write an APL program which calculates the lateral area, surface area, and volume of any like three-dimensional figure.

The student utilizes the 1510 Instructional Display Unit as he progresses through this program, which was designed, and authored, and coded into APL by Catherine E. Morgan.

Terminal Objective

Following the use of the computer units, the student develops coded APL programs for the lateral area, surface area and volume of a sphere, right circular cylinder, right rectangular prism, right circular cone, and a pyramid with a square base.

Comment

Achievement of the terminal objective requires knowledge of APL programming in addition to knowing how to compute the areas and volumes.

253

Computer Program Print-Out

```
  ∇K̲[⎕]∇
∇K̲;A;B
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS'
[5]  B←⎕
[6]  'ONE RESULT IS ';2×3.14×A×B;' SQUARE UNITS'
[7]  'ANOTHER RESULT IS ';(2×3.14×A*2)+2×3.14×A×B;' SQUARE UNITS'
[8]  'THE THIRD RESULT IS ';B×3.14×A*2;' CUBIC UNITS'
 ∇
```

```
  ∇S̲[⎕]∇
∇S̲;A;B;C
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ENTER ANOTHER NUMBER OF UNITS'
[5]  B←⎕
[6]  'ENTER A THIRD NUMBER OF UNITS'
[7]  'WHICH IS LESS THAN THE LAST'
[8]  'NUMBER YOU ENTERED.'
[9]  C←⎕
[10]  'ONE RESULT IS ';3.14×A×B;' SQUARE UNITS'
[11]  'ANOTHER RESULT IS ';(3.14×A×B)+3.14×A*2;' SQUARE UNITS'
[12]  'THE THIRD RESULT IS ';(3.14×C×A*2)÷3;' CUBIC UNITS'
 ∇
```

```
  ∇C̲[⎕]∇
∇C̲;A
[1]  ⌹0
[2]  'ENTER A NUMBER OF UNITS'
[3]  A←⎕
[4]  'ONE RESULT IS ';4×3.14×A*2;' SQUARE UNITS'
[5]  'ANOTHER RESULT IS ';(4÷3)×3.14×A*3;' CUBIC UNITS'
 ∇
```

```
  ∇M̲[⎕]∇
∇M̲;A;B;C
[1]   ⌹0
[2]   'ENTER A NUMBER OF UNITS'
[3]   A←⎕
[4]   'ENTER ANOTHER NUMBER OF UNITS'
[5]   B←⎕
[6]   'ENTER A THIRD NUMBER OF UNITS'
[7]   C←⎕
[8]   'ONE RESULT IS ';(2×A×B)+2×B×C;' SQUARE UNITS'
[9]   'ANOTHER RESULT IS ';(2×A×B)+(2×A×C)+(2×B×C);' SQUARE UNITS'
[10]   ' A THIRD RESULT IS ';A×B×C;' CUBIC UNITS'
 ∇
```

```
  ∇Q̲[⎕]∇
∇Q̲;A;B;C
[1]   ⌹0
[2]   'ENTER A NUMBER OF UNITS'
[3]   A←⎕
[4]   'ENTER ANOTHER NUMBER OF UNITS'
[5]   B←⎕
[6]   'ENTER A THIRD NUMBER OF UNITS'
[7]   'WHICH IS LARGER THAN THE LAST'
[8]   'NUMBER YOU ENTERED'
[9]   C←⎕
[10]   'ONE RESULT IS ';2×A×C;' SQUARE UNITS'
[11]   'ANOTHER RESULT IS ';(2×A×C)+A*2;' SQUARE UNITS'
[12]   'A THIRD RESULT IS ';(1÷3)×B×A*2;' CUBIC UNITS'
 ∇
```

Sample Student Interaction

```
   K
ENTER A NUMBER OF UNITS
⎕:
   10
ENTER ANOTHER NUMBER OF UNITS
⎕:
   20
ONE RESULT IS 1256 SQUARE UNITS
ANOTHER RESULT IS 1884 SQUARE UNITS
THE THIRD RESULT IS 6280 CUBIC UNITS




   S
ENTER A NUMBER OF UNITS
⎕:
   25
ENTER ANOTHER NUMBER OF UNITS
⎕:
   15
ENTER A THIRD NUMBER OF UNITS
WHICH IS LESS THAN THE LAST
NUMBER YOU ENTERED.
⎕:
   10
ONE RESULT IS  1177.5 SQUARE UNITS
ANOTHER RESULT IS 3140 SQUARE UNITS
THE THIRD RESULT IS  6541.67 CUBIC UNITS



   C
ENTER A NUMBER OF UNITS
⎕:
   50
ONE RESULT IS 31400 SQUARE UNITS
ANOTHER RESULT IS  523333 CUBIC UNITS
```

```
  M
ENTER A NUMBER OF UNITS
⎕:
  8
ENTER ANOTHER NUMBER OF UNITS
⎕:
  5
ENTER A THIRD NUMBER OF UNITS
⎕:
  12
ONE RESULT IS 200 SQUARE UNITS
ANOTHER RESULT IS 392 SQUARE UNITS
 A THIRD RESULT IS 480 CUBIC UNITS
```

```
  O
ENTER A NUMBER OF UNITS
⎕:
  25
ENTER ANOTHER NUMBER OF UNITS
⎕:
  30
ENTER A THIRD NUMBER OF UNITS
WHICH IS LARGER THAN THE LAST
NUMBER YOU ENTERED
⎕:
  35
ONE RESULT IS 1750 SQUARE UNITS
ANOTHER RESULT IS 2375 SQUARE UNITS
A THIRD RESULT IS 6250 CUBIC UNITS
```

i. CAR OWNERSHIP

Assessment of Need

Students in high school Consumer Mathematics classes are usually among the first graduates to find employment and to purchase automobiles. Thus the primary purpose of this segment is to make students aware of the expense in financing and operating an automobile. At the same time, this unique program provides a change from the normal arithmetic curriculum.

Description of the Program

Simulation is an interesting technique that is utilized by CAI. Car Ownership is one such program in which the student, interacting with the computer, simulates the purchase of an automobile. His first encounter with the simulation is for motivational purposes. At that time he inputs the initial cost of the car he wishes to purchase, the down payment, and the number of miles he expects to drive in one year and then views the costs of owning and operating that car. Afterwards he returns to the classroom where he receives instruction related to the computer program. Finally, he returns to the terminal to compare his results with the computer's output.

This CAI technique of simulation is employed extensively within the package, which was designed, authored, and coded into APL by Catherine E. Morgan in the fall of 1970.

Terminal Objectives

1. Given the price of an automobile and the fraction or per cent down payment required, the student computes the required down payment. (Fractions restricted to those with denominators of 2, 3, 4 and 5; per cents restricted to integers.)

2. Given the odometer readings before and after filling the gas tank and the number of gallons necessary to fill the tank again after driving for a period of time, the student computes the number of miles per gallon (to the nearest mile).

3. Given the total number of miles driven, the cost of gas per gallon, and the number of miles per gallon, the student computes the cost to drive that distance.

4. Given the price of the car, down payment, monthly payment, and number of monthly payments, the student computes the total cost, including financing.

5. Given a series of tables of figures relating to operation, maintenance, and insurance costs, the student uses the tables to determine costs for his car.

Mode of Presentation

The student uses the IBM 1510 Instructional Display Unit with this APL program. After interacting with the computer at least once, he follows a self-instructional booklet to reach the terminal objectives. At the conclusion of the unit, he prepares a sample print-out, signs on the terminal, runs the program again, and finally compares his computations with those of the computer.

Comments

Students in Consumer Mathematics classes have reacted favorably to this program. Since many students already own automobiles and others will purchase them in the near future, they are understandably motivated by the Car Ownership program, which provides opportunities for them to analyze the cost of owning and operating an automobile.

Sample Section from Instructional Booklet

A. WHAT DOWN PAYMENT NEEDS TO BE MADE ON A CAR?

Most banks lend money to buy automobiles and require a down payment of at least one-third of its cost. *Be careful when a dealer will allow you to take possession of a car with a much lower down payment.*

To compute the necessary down payments, look at these two examples:

Cost of Car	Required Fraction
1.) $3600	1/3
2.) $4000	25%

1.) To find 1/3 of $3600, multiply:

$$1/3 \text{ X } \frac{3600}{1} = \frac{3600}{3}$$

$$\frac{3600}{3} = 1200$$

2.) To find 25% of $4000, change 25% to the fraction 1/4 or a decimal .25, multiply:

$$1/4 \text{ X } 4000 = 1000 \text{ or}$$

$$4000 \text{ X } .25 = 1000$$

Find the required down payments on the following cars:

CAR	TOTAL COST	REQUIRED FRACTION	REQUIRED DOWN PAYMENT
1965 Valiant	800	25%	
1970 Mustang	2700	1/3	
1970 Chevrolet	3000	30%	
1967 Buick	1500	2/5	
1970 Volkswagen	1795	35%	

You will recall that when you first started this booklet, you went to a terminal and called up an APL Program called *CAR OWNERSHIP.* Now that you have a good idea of how to figure the same items that the computer did, you should fill in the items below.

When you have completed your computations on this form, return to the terminal and, using the same information, call up the program again and compare your answers with the computer's answers.

GOOD LUCK!

What price car would you like to buy? $____________

How much down payment would you like to make? ____________
(this down payment should be at least one-third of the cost of the car)

How much do you still owe? ____________

Decide how many years you would pay.
(2, 2.5 or 3 years) ____________

The monthly payment will be $___ for___ months.
(use 7.5% as the rate-of-interest)

How many miles do you expect to drive in one year? ____________

It will cost $___ for gasoline and oil to drive that number of miles.
(use Table I on the opposite page)

Depreciation (use Table II on the opposite page)
At the end of the first year, the car is worth $___, having depreciated $___.

Maintenance (use Table III on the opposite page)
How old is the car you bought? ____________

What is the cost of maintenance? ____________

Insurance (use Table IV on the opposite page)
What will the cost of your insurance be? ____________

Interest and remaining debt

The interest for the first year was $___ and you still owe $___.
(This item is the only one you might be unable to figure – recall that you need a table of amortization.)

Computer Program Print-Out

```
  ∇C[⎕]∇
∇C;A;D;M;T;I;N;P;S;J;K;E;L;Y;Z;Q;B
[1]  ⌹0
[2]  '        CAR OWNERSHIP'
[3]  '  ENTER THE PRICE OF THE AUTOMOBILE YOU WISH TO OWN.'
[4]  A←⎕
[5]  'ENTER THE DOWN PAYMENT YOU WILL BE ABLE TO MAKE.'
[6]  D←⎕
[7]  →(D<⌈A×1÷3)/9
[8]  →11
[9]  'YOUR DOWN PAYMENT MUST BE AT LEAST ';⌈A×1÷3;  '  DOLLARS.'
[10]  →6
[11]  B←A-D
[12]  'YOU MAY PAY OFF THE BALANCE DUE IN 2, 2.5 OR 3 YEARS.'
[13]  'ENTER ONE OF THESE.'
[14]  T←⎕
[15]  →((T=2),(T=2.5),(T=3))/18 18 18
[16]  'YOU MAY ONLY CHOOSE 2, 2.5, OR 3 YEARS.'
[17]  →14
[18]  S←T×12
[19]  P←⌈(B+B×.075×T)÷S
[20]  'INSURANCE IS A MAJOR EXPENSE TO YOUNG ADULTS.'
[21]  'IF YOU ARE UNDER 18 YEARS OF AGE, TYPE 0.'
[22]  ' IF YOU ARE AT LEAST 18 BUT LESS THAN 21 YEARS OLD, TYPE 1.'
[23]  ' IF YOU ARE 21 OR OLDER, TYPE 2.'
[24]  I←⎕
[25]  →((I=1),(I=2))/ 28 30
[26]  J←250
[27]  →31
[28]  J←200
[29]  →31
[30]  J←150
[31]  '  HOW MANY MILES DO YOU EXPECT TO DRIVE IN ONE YEAR?'
[32]  'GENERALLY, PEOPLE DRIVE BETWEEN 6000 AND 10000'
[33]  ' MILES A YEAR.'
[34]  M←⎕
[35]  →(A≥3200)/39
[36]  Y←⌈.25×A
[37]  N←⌈(.6×M÷800)+.359 ×M÷17
[38]  →41
[39]  N←⌈(.6×M÷800)+.389 × M÷12
[40]  Y←⌈.35×A
[41]  ' MAINTENANCE IS MORE EXPENSIVE ON USED CARS, OF COURSE.'
[42]  ' TYPE 1 IF THE CAR YOU CHOSE WAS A NEW ONE.'
[43]  '  IF IT WAS A USED CAR, TYPE 0.'
[44]  K←⎕
[45]  →((K=0),(A≥3500))/50 48
[46]  L←50
[47]  →58
[48]  L←70
[49]  →58
[50]  'ENTER THE AGE OF THE USED CAR YOU CHOSE.'
```

```
[51]  E←⎕
[52]  →((E=1),(E=2),(E=3),(E=4))/55 55 57 57
[53]  L←300
[54]  →58
[55]  L←100
[56]  →58
[57]  L←200
[58]  Z←A-Y
[59]  Q←⌈.075×B
[60]  B←⌈B-(12×P)-Q
[61]  ⌹7,5
[62]  ⌹0
[63]  'YOUR AUTOMOBILE COST ';A;' DOLLARS.'
[64]  'YOUR DOWN PAYMENT WAS ';D;' DOLLARS.'
[65]  '   MONTHLY PAYMENT IS ';P;' DOLLARS FOR  ';S;' MONTHS.'
[66]  'THE COST OF GASOLINE AND OIL FOR DRIVING ';M;' MILES '
[67]  ' IS ';N;'       DOLLARS.'
[68]  '        AT THE END OF ONE YEAR'
[69]  'THE CAR IS NOW WORTH ';Z;' DOLLARS ......'
[70]  ' HAVING DEPRECIATED  ';Y;'  DOLLARS.'
[71]  'YOUR INSURANCE COST IS ';J;' DOLLARS PER YEAR.'
[72]  '   MAINTENANCE ON YOUR CAR WAS  ';L;' DOLLARS THIS YEAR.'
[73]  '  THIS COST WOULD HAVE BEEN LESS IF YOU COULD DO SOME OF THE WORK.
[74]  'YOU HAVE PAID  ';Q;' IN INTEREST AND'
[75]  ' STILL OWE ';B;' DOLLARS.'
[76]  '   '
[77]  ' '
 ∇
```

Sample Student Interaction

```
  C
        CAR OWNERSHIP
  ENTER THE PRICE OF THE AUTOMOBILE YOU WISH TO OWN.
⎕:
  900
ENTER THE DOWN PAYMENT YOU WILL BE ABLE TO MAKE.
⎕:
  150
YOUR DOWN PAYMENT MUST BE AT LEAST 300  DOLLARS.
⎕:
  300
YOU MAY PAY OFF THE BALANCE DUE IN 2, 2.5 OR 3 YEARS.
ENTER ONE OF THESE.
⎕:
  2
INSURANCE IS A MAJOR EXPENSE TO YOUNG ADULTS.
IF YOU ARE UNDER 18 YEARS OF AGE, TYPE 0.
 IF YOU ARE AT LEAST 18 BUT LESS THAN 21 YEARS OLD, TYPE 1.
 IF YOU ARE 21 OR OLDER, TYPE 2.
⎕:
  0
  HOW MANY MILES DO YOU EXPECT TO DRIVE IN ONE YEAR?
GENERALLY, PEOPLE DRIVE BETWEEN 6000 AND 10000
 MILES A YEAR.
⎕:
  2500
 MAINTENANCE IS MORE EXPENSIVE ON USED CARS, OF COURSE.
 TYPE 1 IF THE CAR YOU CHOSE WAS A NEW ONE.
  IF IT WAS A USED CAR, TYPE 0.
⎕:
  0
ENTER THE AGE OF THE USED CAR YOU CHOSE.
⎕:
  5
YOUR AUTOMOBILE COST 900 DOLLARS.
YOUR DOWN PAYMENT WAS 300 DOLLARS.
   MONTHLY PAYMENT IS 29 DOLLARS FOR  24 MONTHS.
THE COST OF GASOLINE AND OIL FOR DRIVING 2500 MILES
 IS 55      DOLLARS.
        AT THE END OF ONE YEAR
THE CAR IS NOW WORTH 675 DOLLARS ......
 HAVING DEPRECIATED  225  DOLLARS.
YOUR INSURANCE COST IS 250 DOLLARS PER YEAR.
   MAINTENANCE ON YOUR CAR WAS  300 DOLLARS THIS YEAR.
  THIS COST WOULD HAVE BEEN LESS IF YOU COULD DO SOME OF THE WORK.
YOU HAVE PAID  45 IN INTEREST AND
 STILL OWE 297 DOLLARS.
```

m. APL REMOTE COMPUTING AND PROGRAM WRITING

Description of the Program

During the first phase of software development, and before extensive curriculum was available, the computer system was used for APL remote computing. All mathematics teachers at Einstein High School were instructed in the APL language and possible implementation related to problem solving. As a result, one mathematics teacher offered to interested students an APL programming course, placing primary emphasis upon computer usage as a problem solving tool. Subsequently, during a four-month period in the early part of 1969, this program was used in an exploratory fashion at the CAI Project.

A direct result of this experience is the following self-instructional unit written by Catherine E. Morgan.

A

PROGRAMMING

LANGUAGE

SELF-INSTRUCTIONAL UNIT
BY KAY MORGAN
1969

APL FOR USE WITH IBM 1500 *INSTRUCTIONAL SYSTEM WITH AN* 1130
CENTRAL PROCESSING UNIT

APL A PROGRAMMING LANGUAGE

GENERAL INFORMATION

PART I

KEYBOARD

NUMERALS, LETTERS AND PUNCTUATION MARKS APPEAR AS USUALLY FOUND ON ANY TYPEWRITER KEYBOARD. HOWEVER, LETTERS ARE ALL IN CAPITALS AND ARE MADE WITHOUT SHIFTING. A SAMPLE KEYBOARD FOLLOWS THIS PAGE. TO HELP YOU AT THE TERMINAL, THE APL SYMBOLS ARE PRINTED AND PASTED IN FRONT OF EACH KEY.

COMMUNICATION

COMMUNICATION BETWEEN THE TERMINAL AND THE COMPUTER OCCURS WHEN ENTRIES ARE MADE FROM THE KEYBOARD. AFTER TYPING AN INSTRUCTION, PRESS THE 'RETURN' KEY TO INDICATE THE END OF THE COMMAND.

ERRORS IN TYPING

ERRORS IN TYPING CAN BE CORRECTED BEFORE ENTERING BY THE FOLLOWING PROCEDURES:

(1) BACKSPACE TO POINT OF ERROR; DEPRESS THE INDEX KEY - THIS WILL ERASE EVERY SYMBOL TO THE RIGHT OF AND INCLUDING THE CURSOR. (FOR TYPEWRITER)

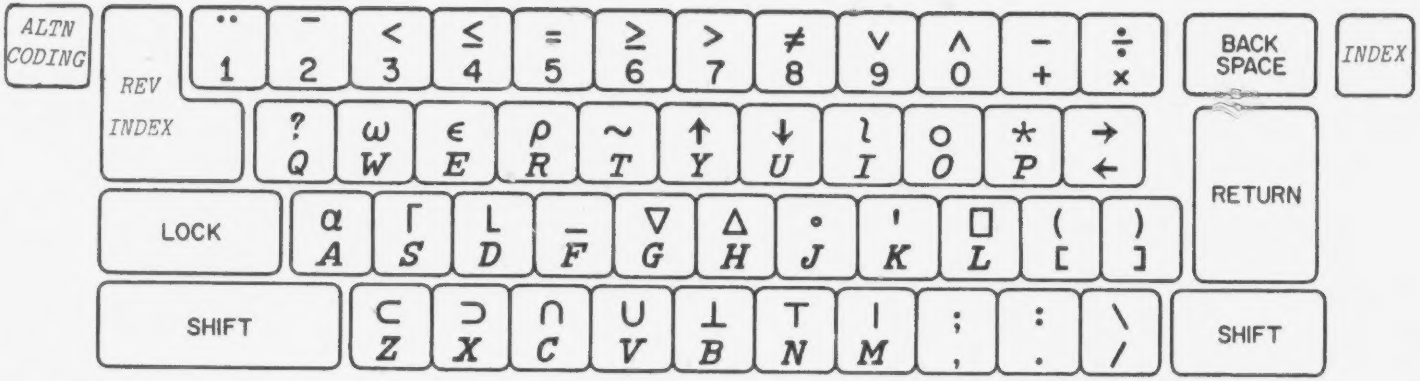
(2) DEPRESS THE PLUS + KEY AND THE ALT CODE KEY AT THE SAME TIME - THIS WILL ERASE THE ENTIRE LINE. (FOR CRT)

(3) DEPRESS THE ALT CODE KEY AND BACKSPACE - THIS WILL ERASE EACH SYMBOL AS YOU BACKSPACE. (FOR CRT)

CONTINUATION

IF YOUR INSTRUCTION IS LONGER THAN ONE LINE, YOU MAY CONTINUE ON THE NEXT LINE BY PRESSING THE ALT CODE KEY AND THE RETURN KEY AT THE SAME TIME.

APL KEYBOARD


ALTN CODING
REV INDEX
¨ 1
¯ 2
< 3
≤ 4
= 5
≥ 6
> 7
≠ 8
∨ 9
∧ 0
− +
÷ ×
BACK SPACE
INDEX
? Q
ω W
∊ E
ρ R
~ T
↑ Y
↓ U
⍳ I
○ O
⋆ P
→ ←
RETURN
LOCK
α A
⌈ S
⌊ D
_ F
∇ G
∆ H
∘ J
' K
⎕ L
([
)]
SHIFT
⊂ Z
⊃ X
∩ C
∪ V
⊥ B
⊤ N
| M
; ,
: .
\ /
SHIFT

TO GAIN ATTENTION OF THE COMPUTER

DEPRESS THE ALT CODE KEY AND THE INDEX KEY AT THE SAME TIME.

TO SIGN ON

GET THE ATTENTION OF THE COMPUTER AS DESCRIBED ABOVE AND THEN TYPE)YOUR APL NUMBER AND PRESS THE RETURN KEY.

EXAMPLE:)348724

THIS ALLOWS YOU A WORKSPACE IN THE COMPUTER SIMILAR TO A PRIVATE SCRATCH PAD AND A PERSONAL NOTEBOOK.

AS SOON AS YOU ARE SIGNED ON, THE FULL APL SYSTEM IS AVAILABLE FOR YOUR USE.

TO SIGN OFF

TYPE)OFF AND PRESS THE RETURN KEY.

PART II THE APL LANGUAGE

STATEMENTS TO THE COMPUTER ARE OF TWO TYPES:

PRIMITIVE FUNCTIONS WHICH ARE PROVIDED BY THE SYSTEM. SOME OF THESE WILL BE LEARNED BY EXPERIMENTATION. SECTION A BELOW DISCUSSES PRIMITIVE FUNCTIONS.

DEFINED FUNCTIONS WHICH YOU, THE USER, PROVIDE BY ENTERING DEFINITIONS OR PROGRAMS. SECTION B ON PAGE 6 EXPLAINS DEFINED FUNCTIONS.

A. PRIMITIVE FUNCTIONS

YOU ARE TO INVESTIGATE THE PRIMITIVE FUNCTIONS OF THE SYSTEM FIRST. TO ASSIST YOU IN LEARNING APL, FOUR INVESTIGATION SHEETS ARE INCLUDED AT THE END IN THIS BOOKLET. THESE SHEETS CONTAIN DIRECTIONS FOR THEIR USE.

PRIMITIVE FUNCTIONS WITH ONLY ONE ARGUMENT (OR NUMBER) SUCH AS

`!A` `÷A` ARE CALLED MONADIC FUNCTIONS.

THOSE FUNCTIONS WHICH REQUIRE TWO ARGUMENTS (OR NUMBERS) SUCH AS

`A÷B` `A⋆B` ARE CALLED DYADIC FUNCTIONS.

WORK ON INVESTIGATION SHEET NO. 1 UNTIL YOU ARE SATISFIED THAT YOU KNOW WHAT EACH OF THE GIVEN APL COMMANDS IS DOING.

INVESTIGATION SHEET NO. 2 ALLOWS YOU TO DISCOVER HOW APL TREATS SCALARS AND VECTORS. IT FURTHER ASKS YOU TO DISCOVER WHAT APL DOES WITH STATEMENTS OF LOGIC.

SINGLE NUMBERS SUCH AS

```
17
3.14159
¯10
3000000
```

ARE CALLED SCALARS.

LISTS OF TWO OR MORE NUMBERS SUCH AS

```
7, 3, 42, .34, 9000000
¯49, .111111111
```

ARE CALLED VECTORS.

INVESTIGATION SHEET NO. 3 ALLOWS YOU TO DISCOVER THE ORDER IN WHICH APL COMPUTES WHEN NO PARENTHESES ARE USED.

> THE ORDER OF OPERATIONS USED IN APL IS DIFFERENT FROM THAT USED IN MATHEMATICS. OF COURSE, IF PARENTHESES ARE USED IN EXPRESSIONS, THEN THE RESULTS ARE IDENTICAL.

INVESTIGATION SHEET NO. 4 ILLUSTRATES SOME COMMON ERRORS AND THE ERROR MESSAGES SENT BY THE COMPUTER.

> ALTHOUGH ERROR MESSAGES CAN BE IGNORED WHEN YOU ARE USING THE COMPUTER AS YOU HAVE BEEN, IT IS IMPORTANT TO BE ABLE TO CORRECT ERRORS WHEN IN FUNCTION DEFINITION MODE.

SOME MORE GENERAL INFORMATION - SUPPOSE YOUR WORKSPACE BECOMES FULL - THE COMPUTER WILL SEND YOU A MESSAGE.

```
WS FULL
```

IF YOU RECEIVE SUCH A MESSAGE, TYPE `)CLEAR` AND YOU WILL HAVE A CLEAN WORKSPACE INSIDE THE COMPUTER.

THIS MESSAGE WILL NOT CLEAR UP A MESSY SCREEN. YOU NEED TO TYPE ⌹0 (DOMINO ZERO) FIRST YOU TYPE ⎕, BACKSPACE, TYPE ÷, AND THEN 0.

B. DEFINED FUNCTIONS

AT THIS POINT YOU ARE READY TO WRITE A PROGRAM WHICH YOU MIGHT USE MORE THAN ONCE AND WHICH YOU MIGHT WISH TO STORE IN THE COMPUTER.

SUPPOSE YOU WISH TO WRITE A PROGRAM WHICH WILL COMPUTE THE AVERAGE OF A GROUP OF TEST SCORES, PLUS SOME OTHER INFORMATION. LET'S CALL THIS PROGRAM A. FIRST YOU MUST TYPE `)LOAD` THEN, TYPE ∇A (CALLED DEL A). THE COMPUTER THEN PRINTS [1] AND YOU TYPE YOUR FIRST STATEMENT.

```
∇A
[1]  'THE NUMBER OF SCORES IS'
[2]  ⍴S
[3]  'THE HIGHEST SCORE IS'
[4]  ⌈/S
[5]  'THE LOWEST SCORE IS'
[6]  ⌊/S
[7]  'THE AVERAGE SCORE IS'
[8]  +/S÷⍴S
[9]  ∇
```

LET'S USE OUR PROGRAM.

FIRST TYPE A VECTOR OF SCORES FOR S

```
S←90  86  72  65  100  88  85  92
```

THEN TYPE A

ON THE SCREEN WILL APPEAR THE FOLLOWING:

```
THE NUMBER OF SCORES IS

8

THE HIGHEST SCORE IS

100

THE LOWEST SCORE IS

65

THE AVERAGE SCORE IS

86
```

IF THE PROGRAM WORKS THE WAY YOU WISH, AND YOU WISH TO STORE IT IN THE COMPUTER, TYPE `)SAVE`

IF YOU WISH TO VIEW WHAT YOU WROTE, TYPE

```
     ∇A[⎕]∇
```

AND THE PROGRAM WILL BE DISPLAYED.

IF YOU WISH TO MAKE AN ADDITION TO YOUR PROGRAM, TYPE

```
     ∇A
```

AND THE COMPUTER WILL PRINT [9] *AND YOU CAN ADD ANY STEPS YOU WISH.*

IF YOU WISH TO CHANGE STEP 4, *TYPE* ∇*A AND WHEN* [9] *APPEARS, TYPE*

[9] [4] *AND CHANGE STEP* 4 *IN ANY WAY YOU WANT*

THEN

[5] *WILL APPEAR ON THE SCREEN AND YOU MAY CHANGE STEP* 5. *IF YOU WANT TO LEAVE STEP* 5 *AS IT WAS ORIGINALLY, TYPE* ∇.

ERRORS IN DEFINITIONS MUST BE CORRECTED. TO DO SO AFTER YOU RECEIVE AN ERROR MESSAGE FOR A CERTAIN LINE, YOU MUST TYPE `)PURGE` *TO BE ABLE TO MAKE CORRECTIONS.*

PEOPLE WHO USE APL HAVE MORE FUN !

INVESTIGATION SHEET NO. 1

USE RATIONAL NUMBERS FOR A, B, C ... TRY A VARIETY OF NUMBERS IN YOUR DISCOVERY OF WHAT THE FUNCTION DOES. WRITE IN THE SPACE PROVIDED WHAT FUNCTION EACH COMMAND DOES. TWO FUNCTIONS HAVE BEEN FILLED IN.

TYPE	*FUNCTION*
A+B	*A+B*
A-B	
A×B	
A÷B	
+A	*A* + 0
-A	
÷A	
A⋆B	
A⌈B	
A⌊B	
A?B	
⌈A	
⌊A	
|A	
!A	
?A	
[illegible]*A*	

INVESTIGATION SHEET NO. 2

TYPE	FUNCTION
⍳ A (IOTA - SHIFTED I)	
⍴ A B C (RHO - SHIFTED R)	
A + B C D E	
A B C × D E F	
A ⋆ B C D	
A ÷ ⍳B	
+/ A B C D	
×/⍳A	
LOGIC	
A > B	
A < B	
A = B	
A ≠ B	
A ≥ B	
A ≤ B	

INVESTIGATION SHEET NO. 3

EXPRESSION	MATHEMATICAL NAME	APL NAME	WRITE THE EXPRESSION WITH THE LEAST NUMBER OF PARENTHESES THAT WILL NORMALLY GIVE THE SAME ANSWER.
7+4-5			
8+2×6			
8×2+6			
14×2÷10÷1			
4÷3×3.14×7*3			
2×2*3			
2*2×3			
1130+.25÷6732.57-6000			
6*2×7÷9÷¯3			

REARRANGE THESE EXPRESSIONS SO THEY WILL GIVE THE INTENDED RESULTS IN APL, USING NO PARENTHESES.

3÷5×10	6
3×5+6	21
3-1÷4×8	40
75-31×.1+15	19.4

INVESTIGATION SHEET NO. 4

ERROR MESSAGES

TYPE	MESSAGE	REASON
A×7		
JOHN		
7÷0		
7?3		
3 2 6 + 7 8		
ι400		

4. SENIOR HIGH SCHOOL CHEMISTRY AND PHYSICS

by

John M. Boblick

a. Using the Oxidation Potential Table

b. Writing Chemical Formulas

c. Balancing Chemical Equations

d. An Acid-Base Titration

e. The Gas Laws

f. Construction of a Lens

g. The Force Between Charged Particles

h. Motion in the Earth's Gravitational Field

i. A One-Dimensional Elastic Collision

j. The Area Under a Curve

k. The Analysis of Laboratory Data

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AUTHOR

As one of the three original teacher specialists to join the CAI Project in June, 1968, John M. Boblick designed and authored eleven modular instructional packages in chemistry and physics. Eight of these MIP's he programmed into APL, while three were coded into COURSEWRITER II by staff programmers.

Mr. Boblick earned both his Bachelor of Science and Masters of Education Degrees at Indiana (Pa.) State College with a major in physical science. After three years of teaching in the Pennsylvania public schools, he accepted a position in Montgomery County, Maryland, where he taught physics and chemistry at Einstein High School from 1962 until June, 1968. In the spring of 1968, he was selected by the project director, William M. Richardson, to develop programs for high school chemistry and physics students. He, together with the other two teacher specialists, received training in educational technology after joining the CAI Project.

a. USING THE OXIDATION POTENTIAL TABLE

Assessment of Need

The need for this modular instructional package was determined by the author, John M. Boblick, as a result of his classroom experiences.

Description of the Program

An off-line test is used for assessing mastery of the necessary entering behaviors for this program. Following successful completion of this test, the student interacts with the IBM 1510 Instructional Display with light pen. He receives instruction on the use of an oxidation potential table, then proceeds with a drill and practice session by selecting pairs of substances which will react spontaneously. At the end of each session, the student has the choice of continuing with further drill or taking an off-line posttest designed to measure attainment of the terminal objective. The MIP, completed in August, 1969, was coded into COURSEWRITER II by Chris Eshleman, Priscilla Smith, and Sandra Bassett.

Terminal Objective

Given five pairs of chemical substances selected from an oxidation potential table, the student identifies the pairs that will react spontaneously when combined.

Entering Behaviors

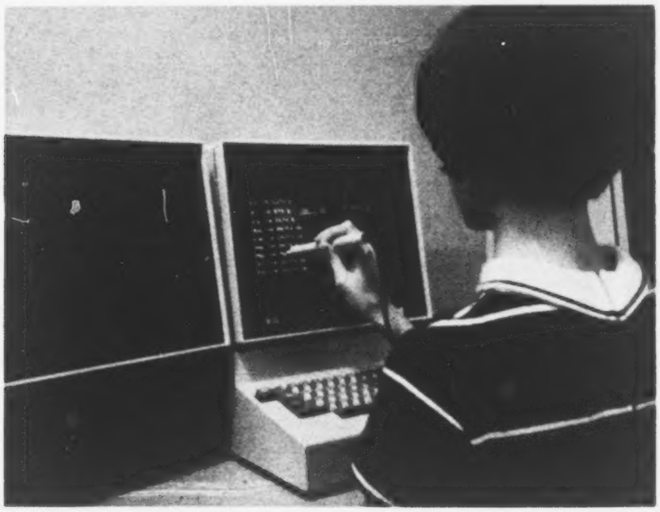
The student:

1. Defines oxidation and reduction in terms of electron gain or loss.

2. Identifies the substance within a redox reaction which is oxidized and the substance which is reduced.

3. Identifies the oxidation numbers of substances involved in chemical reactions.

4. Distinguishes between reactants and products within a chemical reaction.



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Pretest

Using the Oxidation Potential Table

Listed below are several pairs of possible reactants in redox reations. Use your oxidation potential table to predict if the reaction will take place spontaneously. If the substances will react spontaneously, answer *yes.* If they will not react spontaneously, answer *no.*

		Yes	No
1.	$Cs + Ba^{+2}$	( )	( )
2.	$Mg^{+2} + Cu^{+2}$	( )	( )
3.	$Na + Zn^{+2}$	( )	( )
4.	$Li + K^{+}$	( )	( )
5.	$Ca + Ca^{+2}$	( )	( )

Posttest

Using the Oxidation Potential Table

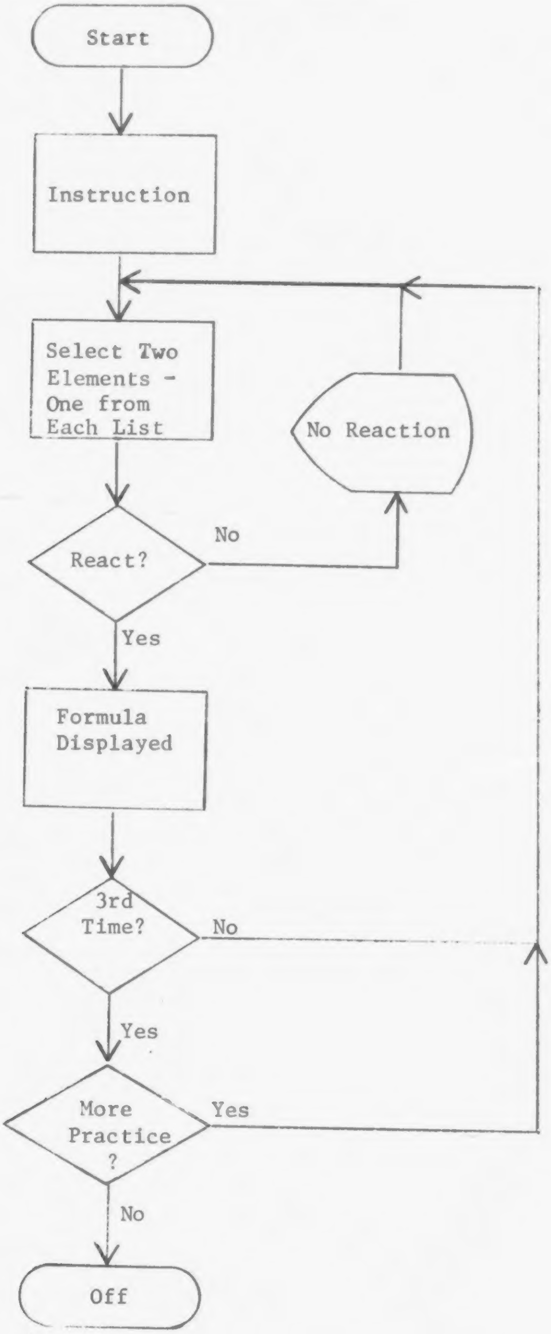
Listed below are several pairs of possible reactants in redox reations. Use your oxidation potential table to predict if the reaction will take place spontaneously. If the substances will react spontaneously, answer *yes.* If they will not react spontaneously, answer *no.*

		Yes	No
1.	$Pb + Ag^{+}$	( )	( )
2.	$H + Pb^{+2}$	( )	( )
3.	$Ag + Fe$	( )	( )
4.	$Fe + Hg^{+2}$	( )	( )
5.	$Al + Al^{+3}$	( )	( )

Mode of Presentation

This modular instructional package primarily makes use of the CAI technique drill and practice. All assessment is provided off-line.

USING THE OXIDATION POTENTIAL - INSTRUCTIONAL STRATEGY


Start
Instruction
Select Two Elements - One from Each List
React?
No
No Reaction
Yes
Formula Displayed
3rd Time?
No
Yes
More Practice ?
Yes
No
Off

Sample Section of Program

$Ba + Cu^{+2} \longrightarrow Ba^{+2} + Cu$

Is Cu^{+2} oxidized or reduced?

For a oxidation-reduction reaction to take place spontaneously:

Rule 1 The substance to be oxidized must appear in the left column of the table.

Rule 2 The substance to be reduced must be in the right column.

Rule 3 The substance in the left column must be higher on the table than the substance in the right column.

$Zn + Cs^{+} \longrightarrow$

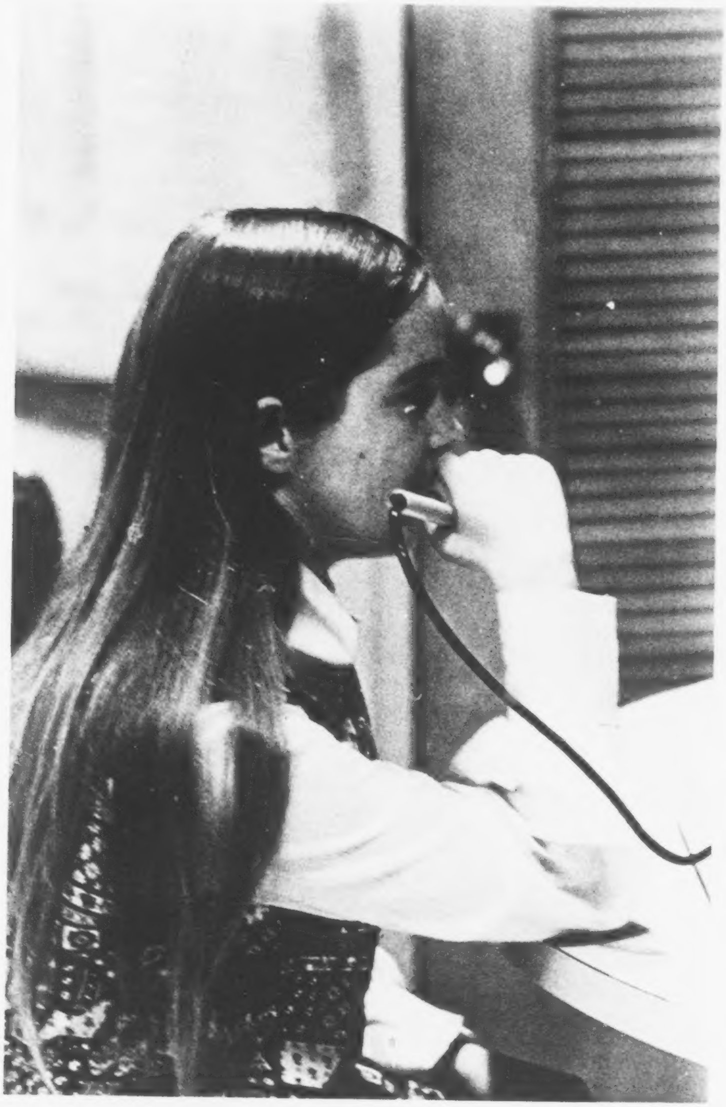
Will a reaction occur when these substances are combined?

☐ Yes ☐ No

P

Comment

A validation study for this program was conducted with 47 chemistry students during the fall semester of 1969. For further details, see Validation Data, Section E.



b. WRITING CHEMICAL FORMULAS

Assessment of Need

Among the basic skills which must be acquired by chemistry students is the ability to write the chemical formula of a compound when given the compound's name. In addition, the chemistry student, if given the formula of a compound, must be able to name the compound. Chemistry teachers at the project school felt a need existed for improving the method of teaching the skills of writing formulas; thus, a computer-assisted instruction program was developed to remedy this problem.

Descripton of the Program

This tutorial program, authored by John M. Boblick, may be employed in a variety of ways to provide instruction in the writing of chemical formulas and the naming of inorganic chemical compounds. It may also be used as initial instruction in writing formulas. In this mode of instruction, the student takes a diagnostic test which determines the path of instruction he will follow. Successfully answering the series of questions which pertain to a given enabling objective allows the student to bypass instruction on a behavior he has already acquired. In this way a student is given only the instruction he needs. On-line, he utilizes the 1510 Instructional Display with light pen and student booklet.

This program was completed in August, 1969, and programmed into COURSEWRITER II by Chris Eshleman.

Terminal Objective

Given the name of a compound, the student writes the chemical formula; and given the formula of the compound, he names the compound.

Enabling Objectives

The student:

1. Defines a formula as representing one mole of a chemical compound.
2. Defines a chemical radical.
3. Given a chemical formula of a compound and a list of names and the symbols of the chemical elements, identifies those elements present in the compound from the symbols used in the formula.
4. Given a chemical formula of a compound and a list of names and the formulas of the common radicals, identifies those radicals present within the compound.
5. Writes the element or radical with the most positive oxidation number first (leftmost) in the formula.
6. Writes the element or radical with the most negative oxidation number last (rightmost) in the formula.

7. Interprets the subscript following a chemical symbol or radical within a formula as indicating the number of moles of that element or radical within one mole of the compound.

8. Indicates the presence of two or more moles of a radical within one mole of the compound by enclosing the formula of the radical in parentheses and placing outside and following the parentheses the subscript which numerically equals the number of moles of the radical present.

9. Calculates the number of moles of each element that comprises a radical within a compound by multipying the number of moles of each element within the radical by the subscript following the parentheses which enclose the radical.

10. Calculates the sum of the oxidation numbers of the elements comprising the compound.

11. Interprets a sum of zero for the oxidation numbers of the elements within a formula as an indication that the formula is correctly written.

12. Selects a set of integers which, when multiplied by the number or moles of each element and/or radical within the formula, will give a net oxidation number of zero.

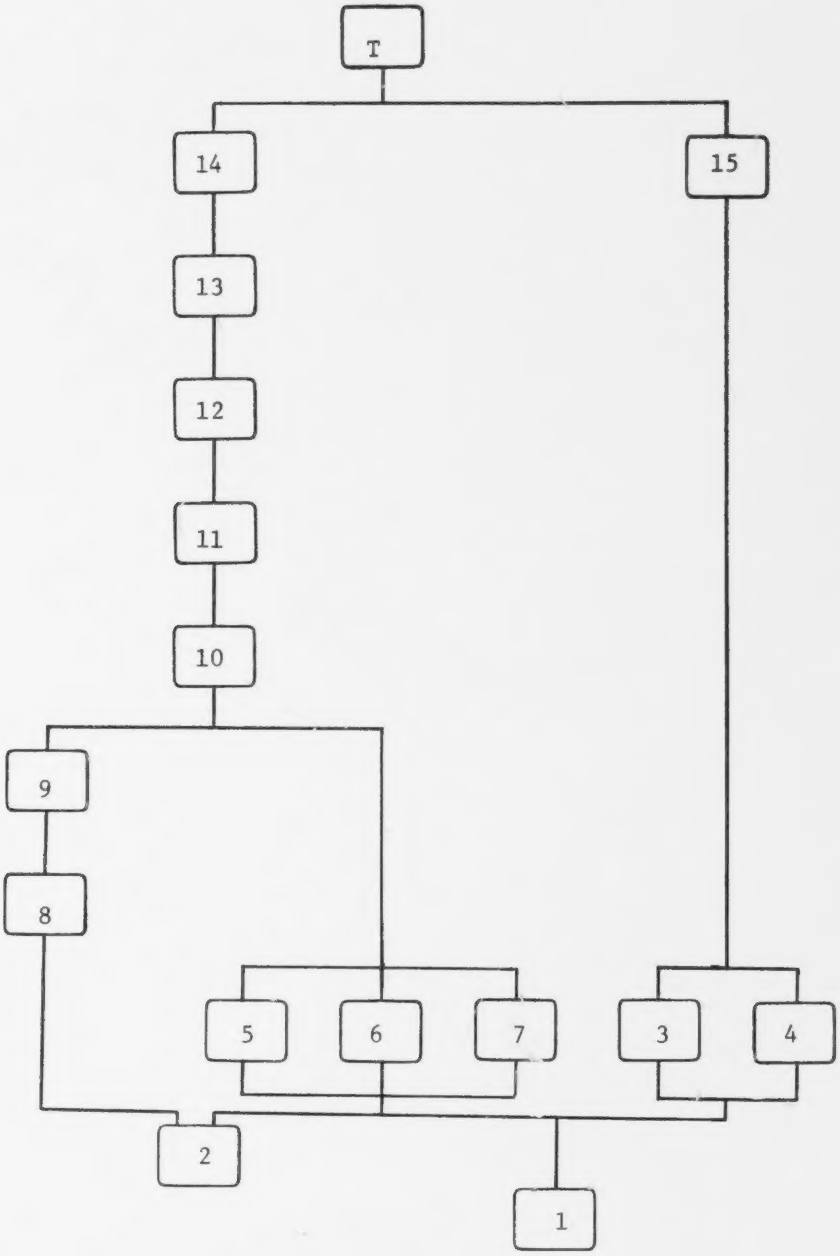
13. Writes the lowest set of integers which gives a net oxidation number of zero for the compound as subscripts following the appropriate symbol or radical.

14. Given the name of a chemical compound, writes the formula of that compound.

15. Given the formula of a compound, states the chemical name of the compound.

___ gm.
___ gm.
___ gm.
___ gm.
NaCl salt water
2
125.82
125.80

WRITING CHEMICAL FORMULAS - HIERARCHY


T
14
15
13
12
11
10
9
8
5
6
7
3
4
2
1

Pretest

The pretest, consisting of eight items on the terminal objective, is administered off-line to determine those students who should take the CAI program.

Posttest – CHEM–10

1. The name of the compound, whose formula is SrF_2, is ____________________.

    strontium iodide
    silver phosphide
    silver fluoride
    strontium fluoride

2. The compound, $(NH_4)_2SO_4$, is named____________________.

    ammonium sulfite
    ammonium sulfate
    nitrogen hydrogen sulfate
    sulfamilamide

3. The name of the compound with the formula, Na_2S, is____________________.

4. The name of the compound with the formula, $Ba(NO_2)_2$, is____________________.

5. The formula of the compound, barium iodide, is____________________.

    BI_2

    BaI_2

    Ba_2I

    $BaIO_3$

6. The formula of the compound, calcium sulfate, is ____________________.

    $CaSO_4$

    Ca_2SO_4

    $Ca(SO_4)_2$

    $Cd(SO_3)_2$

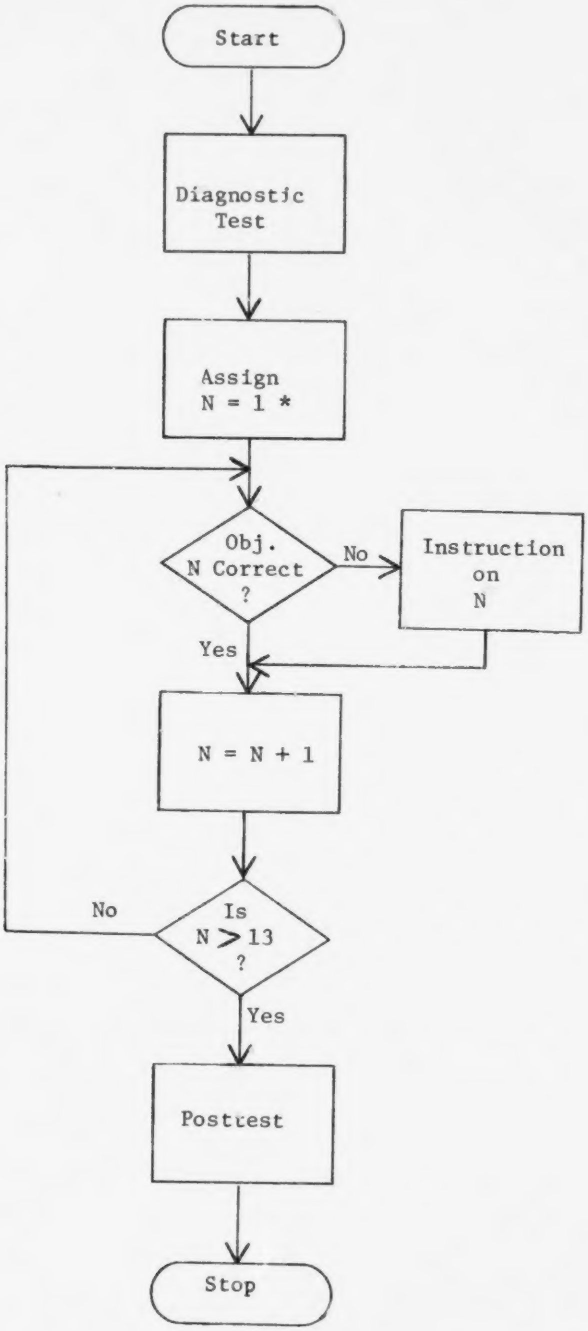
7. The formula of potassium bromide is____________________.

8. The formula of the compound, aluminum acetate, is____________________.

Mode of Presentation

The diagnostic capabilities of this program make it suitable for remedial instruction at any time within the school year that a student develops difficulties in writing formulas. Once the teacher has identified the tutorial instruction needed by a student, he may assign only that portion of the program which provides that specific instruction. When there is doubt as to what instruction is needed, the program will determine that for the teacher.

WRITING CHEMICAL FORMULAS - INSTRUCTIONAL STRATEGY


Start
Diagnostic Test
Assign N = 1 *
Obj. N Correct ?
No
Instruction on N
Yes
N = N + 1
No
Is N > 13 ?
Yes
Posttest
Stop

* N = Obj. 1

Sample Section of Program

At the end of this lesson you will be able to:

A. Given the formula of a compound, state the chemical name of the compound.

B. Given the chemical name of the compound, write the formula of the compound.

S

If you have a dozen apples, you have 12 apples. If you have a mole of apples, you have 6.02×10^{23} apples.

Just as a dozen beakers is 12 beakers, a mole of beakers is 6.02×10^{23} beakers.

S

The formula, $C_{12}H_{22}O_{11}$, represents one _______ of sucrose (sugar).

A atom

B molecule

C mole

D ton

P

Let's try another. The name of the compound, $Mg(OH)_2$, is:

- A magnesium oxide
- B manganese hydroxide
- C magnesium hydroxide
- D milk of magnesia.

P

The formula SrS_2 is incorrectly written. The sum of the oxidation numbers is:

1 mole Sr	+2
2 moles S (at -2 per mole)	-4
SUM	-2

To be correctly written the sum of the oxidation numbers must be ZERO.

S

Type the correct formula for the compound formed by the combination of Sr and S.

____

K

Groups of atoms which act as a group as the SO_4^{-2} group did in the previous reaction are called RADICALS.

S

Stored within a chemical reference table is a list of common radicals. You can look at this table by pressing the letter i. After viewing the table, you will be returned to this point in the program.

If you do not wish to view the table of common radicals, press the space bar.

S

Let's try another formula. What is the name of CaO? Ca represents calcium and O represents oxygen, so the name of the compound is:

A	calcium oxygen	C	lime
B	calcium oxide	D	lemon

P

Comments

Writing chemical formulas is a skill which must be acquired by all chemistry students. The use of this computer program may permit this skill to be gained more rapidly by providing an individualized program of instruction for each student. A validation study for the program was conducted with 27 chemistry students during the spring of 1970. See Validation Data, Section E, for details.

c. BALANCING CHEMICAL EQUATIONS

Assessment of Need

Balancing chemical equations is a fundamental concept area within the senior high school chemistry curriculum. Acquisition of this skill usually involves much practice. To provide extensive practice and immediate feedback, the modular instructional package, Balancing Chemical Equations, was written.

Description of the Program

After receiving initial instruction from the teacher on balancing equations, the student is given four lists of equations from which the drill assignment is made. The teacher may assign specific equations to be balanced, or he may allow the student to select the equations from the list. At the IBM 1510 Instructional Display, the student enters the number of the equation list and the particular equation he wishes to balance, using the keyboard and light pen. The balancing of this equation is done off-line. When the result has been obtained, the student enters his answer at the terminal and receives immediate evaluation. If it is incorrect, the program lists each coefficient of the element, indicating if it is correct, too small, or too large. The student is then given two additional opportunities to balance the equation. If after these attempts it is still incorrect, the proper set of coefficients is displayed on the CRT, and he goes on to another equation.

This drill and practice was designed, authored, and programmed into APL by John M. Boblick, teacher specialist in curriculum.

Terminal Objective

Given a chemical equation with the formulas of the reactants and products written, the student balances the equation by supplying the proper coefficients for each substance.

Entering Behaviors

The student:

1. Identifies the reactants and products of a chemical equation.

2. Indicates more than one mole of an element or compound present in an equation by placing the appropriate integer in front of the symbol or formula.

3. Defines a coefficient as an integer preceding a symbol or formula which indicates the number or moles of that element or compound.

4. When given a list of common elements and radicals, identifies those elements and radicals that appear in a chemical equation.

Pretest

BALANCING CHEMICAL EQUATIONS FORM A

Balance each of the following equations by placing the proper coefficients in the spaces provided.

1. _____ Mg + _____ $H_2O \rightarrow$ _____ $Mg(OH)_2$ + _____ H_2
2. _____ NH_4OH + _____ $H_2SO_4 \rightarrow$ _____ H_2O + _____ $(NH_4)_2SO_4$
3. _____ Al + _____ $F_2 \rightarrow$ _____ AlF_3
4. _____ MgO + _____ $H_2O \rightarrow$ _____ $Mg(OH)_2$
5. _____ $AgNO_3$ + _____ $Cu \rightarrow$ _____ Ag + _____ $Cu(NO_3)_2$

Posttest

BALANCING CHEMICAL EQUATIONS FORM B

Balance the following equations by placing the proper coefficients in the spaces provided.

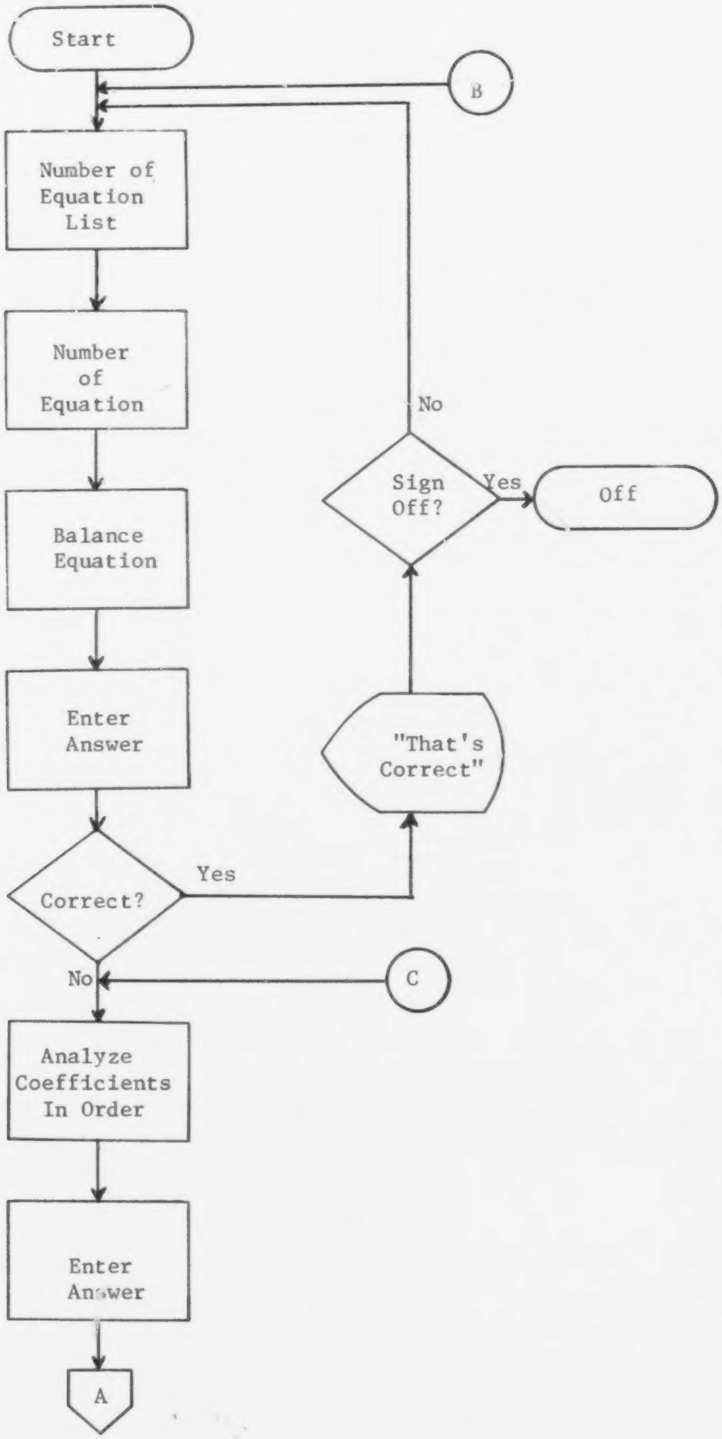
1. _____ Ca + _____ $HCl \rightarrow$ _____ $CaCl_2$ + _____ H_2
2. _____ $SbCl_3$ + _____ $H_2S \rightarrow$ _____ Sb_2S_3 + _____ HCl
3. _____ Fe + _____ $Cl_2 \rightarrow$ _____ $FeCl_3$
4. _____ SO_3 + _____ $H_2O \rightarrow$ _____ H_2SO_4
5. _____ $HgNO_3$ + _____ $Zn \rightarrow$ _____ Hg + _____ $Zn(NO_3)_2$

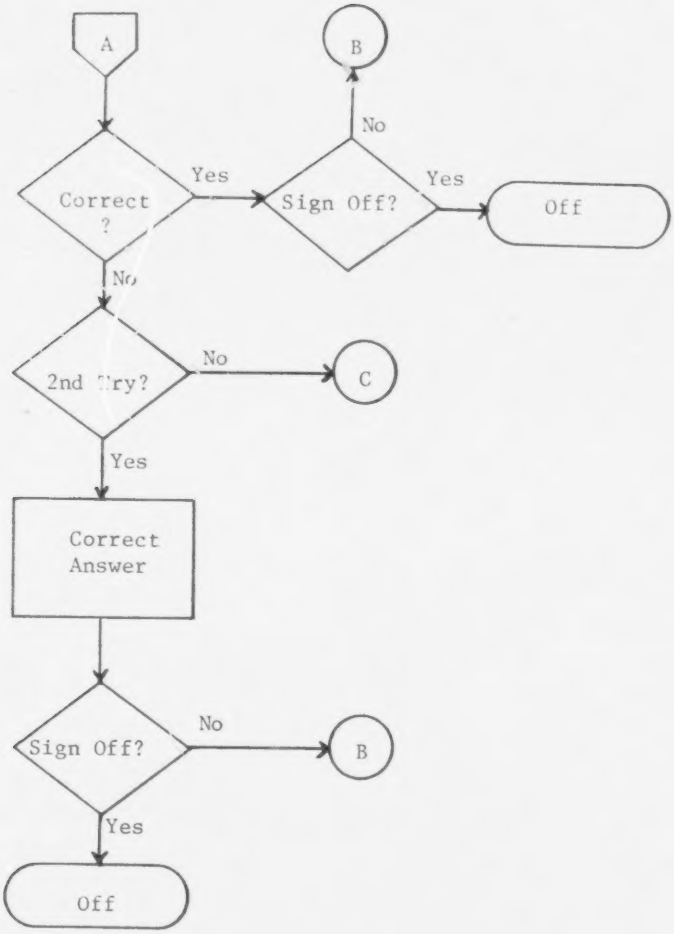
Computer Program Printout

```
  ∇B[⎕]∇
∇B;L̲;N;T;W;X;C;C̲;N̲;T̲
[1]  ⌸0
[2]  ⌸4,4
[3]  'BALANCING CHEMICAL EQUATIONS'
[4]  ⌸4,7
[5]  'AUTHOR  JOHN M. BOBLICK'
[6]  'JANUARY 1970'
[7]  ⌸7,240
[8]  ⌸0
[9]  'ENTER THE NUMBER (1 2 3 4) OF'
[10]  'THE EQUATION LIST.'
[11]  L̲←⎕
[12]  T̲←T←W←X←0
[13]  'SELECT AN EQUATION FROM THE LIST IN YOUR'
[14]  'BOOKLET. ENTER THE NUMBER OF THE'
[15]  'EQUATION.'
[16]  N←⎕
[17]  →81×⍳(N=0)
[18]  N←6|N
[19]  T←T+1
[20]  ⌸0
[21]  'BALANCE THE EQUATION AND ENTER THE'
[22]  'COEFFICIENTS OF THE SUBSTANCES IN THE'
[23]  'EQUATION IN THE SAME ORDER (LEFT TO'
[24]  'RIGHT) AS THE SUBSTANCES APPEAR'
[25]  'IN THE EQUATION.'
[26]  T̲←T̲+1
[27]  →((L̲=1),(L̲=2),(L̲=3),(L̲=4))/28 28 35 42
[28]  →((N=1),(N=2),(N=3),(N=4),(N=5))/30 31 32 33 34
[29]  →49,C←2 1 2
[30]  →49,C←1 1 1
[31]  →49,C←2 1 2 1
[32]  →49,C←2 3 2
[33]  →49,C←1 1 1 2
[34]  →49,C←1 2 1 1
[35]  →((N=1),(N=2),(N=3),(N=4),(N=5))/37 38 39 40 41
[36]  →49,C←1 3 2 3
[37]  →49,C←1 1 2
[38]  →49,C←2 2 2 1
[39]  →49,C←2 3 1 6
[40]  →49,C←1 3 1 3
[41]  →49,C←4 3 3 2
[42]  →((N=1),(N=2),(N=3),(N=4),(N=5))/44 45 46 47 48
[43]  →49,C←2 3 4 3
[44]  →49,C←1 1 2
[45]  →49,C←2 3 1 3
[46]  →49,C←2 1 2 1
[47]  →49,C←2 1 2
[48]  C←2 4 3
[49]  C̲←⎕
[50]  →78×⍳((⍴C̲)≠(⍴C))
```

```
[51]  ⌹0
[52]  →(⌊/(C=C̲))/73
[53]  L←'ABCD'
[54]  N̲←1
[55]  →((C̲[N̲]>C[N̲]),(C̲[N̲]=C[N̲]))/58 60
[56]  'THE COEFFICIENT FOR ';L[N̲];' IS TOO SMALL.'
[57]  →61
[58]  'THE COEFFICIENT FOR ';L[N̲];' IS TOO LARGE.'
[59]  →61
[60]  'THE COEFFICIENT FOR ';L[N̲];' IS CORRECT.'
[61]  N̲←N̲+1
[62]  →55×⍳(N̲≤⍴C)
[63]  W←W+1
[64]  →68×⍳(T̲≥3)
[65]  'TRY THAT EQUATION AGAIN.'
[66]  ⌹7,100
[67]  →20
[68]  'THE CORRECT SET OF COEFFICIENTS IS ';C
[69]  'TRY ANOTHER EQUATION.'
[70]  ⌹7,600
[71]  ⌹0
[72]  →13,T̲←0
[73]  'THAT''S CORRECT. TRY ANOTHER EQUATION.'
[74]  T̲←0
[75]  ⌹7,240
[76]  ⌹0
[77]  →13,X←X+1
[78]  'ENTER ONE COEFFICIENT FOR EACH'
[79]  'SUBSTANCE IN THE EQUATION.'
[80]  →49
[81]  ⌹0
[82]  'YOUR PERFORMANCE ON THIS DRILL IS:'
[83]  'EQUATION LIST         ';L̲
[84]  'EQUATIONS TRIED       ';T
[85]  'CORRECT ANSWERS       ';X
[86]  'WRONG ANSWERS         ';W
[87]  'PER CENT CORRECT      ';100×X÷(X+W)
 ∇
[88]
```

BALANCING CHEMICAL EQUATIONS - INSTRUCTIONAL STRATEGY


Start
B
Number of Equation List
Number of Equation
Balance Equation
Enter Answer
Correct?
Yes
No
C
Analyze Coefficients In Order
Enter Answer
A
"That's Correct"
Sign Off?
Yes
No
Off


A
Correct ?
Yes
Sign Off?
No
B
Yes
Off
No
2nd Try?
No
C
Yes
Correct Answer
Sign Off?
No
B
Yes
Off

Sample Student Interaction

```
      B
BALANCING CHEMICAL EQUATIONS
AUTHOR  JOHN M. BOBLICK
JANUARY 1970
ENTER THE NUMBER (1 2 3 4) OF
THE EQUATION LIST.
⎕:
      2
SELECT AN EQUATION FROM THE LIST IN YOUR
BOOKLET. ENTER THE NUMBER OF THE
EQUATION.
⎕:
      1
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
      1 1 1
THAT'S CORRECT. TRY ANOTHER EQUATION.
SELECT AN EQUATION FROM THE LIST IN YOUR
BOOKLET. ENTER THE NUMBER OF THE
EQUATION.
⎕:
      9
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
      3 3 2
THE COEFFICIENT FOR A IS TOO LARGE.
THE COEFFICIENT FOR B IS CORRECT.
THE COEFFICIENT FOR C IS CORRECT.
TRY THAT EQUATION AGAIN.
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
      2 3 2
```

```
THAT'S CORRECT. TRY ANOTHER EQUATION.
SELECT AN EQUATION FROM THE LIST IN YOUR
BOOKLET. ENTER THE NUMBER OF THE
EQUATION.
⎕:
   20
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
   2 1 1 2
THE COEFFICIENT FOR A IS CORRECT.
THE COEFFICIENT FOR B IS CORRECT.
THE COEFFICIENT FOR C IS TOO SMALL.
THE COEFFICIENT FOR D IS TOO LARGE.
TRY THAT EQUATION AGAIN.
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
   2 1 2 1
THAT'S CORRECT. TRY ANOTHER EQUATION.
SELECT AN EQUATION FROM THE LIST IN YOUR
BOOKLET. ENTER THE NUMBER OF THE
EQUATION.
⎕:
   12
BALANCE THE EQUATION AND ENTER THE
COEFFICIENTS OF THE SUBSTANCES IN THE
EQUATION IN THE SAME ORDER (LEFT TO
RIGHT) AS THE SUBSTANCES APPEAR
IN THE EQUATION.
⎕:
   2 1 2
THAT'S CORRECT. TRY ANOTHER EQUATION.
SELECT AN EQUATION FROM THE LIST IN YOUR
BOOKLET. ENTER THE NUMBER OF THE
EQUATION.
⎕:
   0
YOUR PERFORMANCE ON THIS DRILL IS:
EQUATION LIST        2
EQUATIONS TRIED      4
CORRECT ANSWERS      4
WRONG ANSWERS        2
PER CENT CORRECT      66.6667
```

Comment

This program has been used with chemistry students at the senior high school level; however, validational data has not been collected.

d. AN ACID-BASE TITRATION

Assessment of Need

This simulation provides the chemistry student with opportunities to practice the technique of determining the strength of an acid by titration with a standardized base. Utilizing this program, the student is no longer required to spend hours working with caustic acids and bases to demonstrate his understanding of these concepts.

Description of the Program

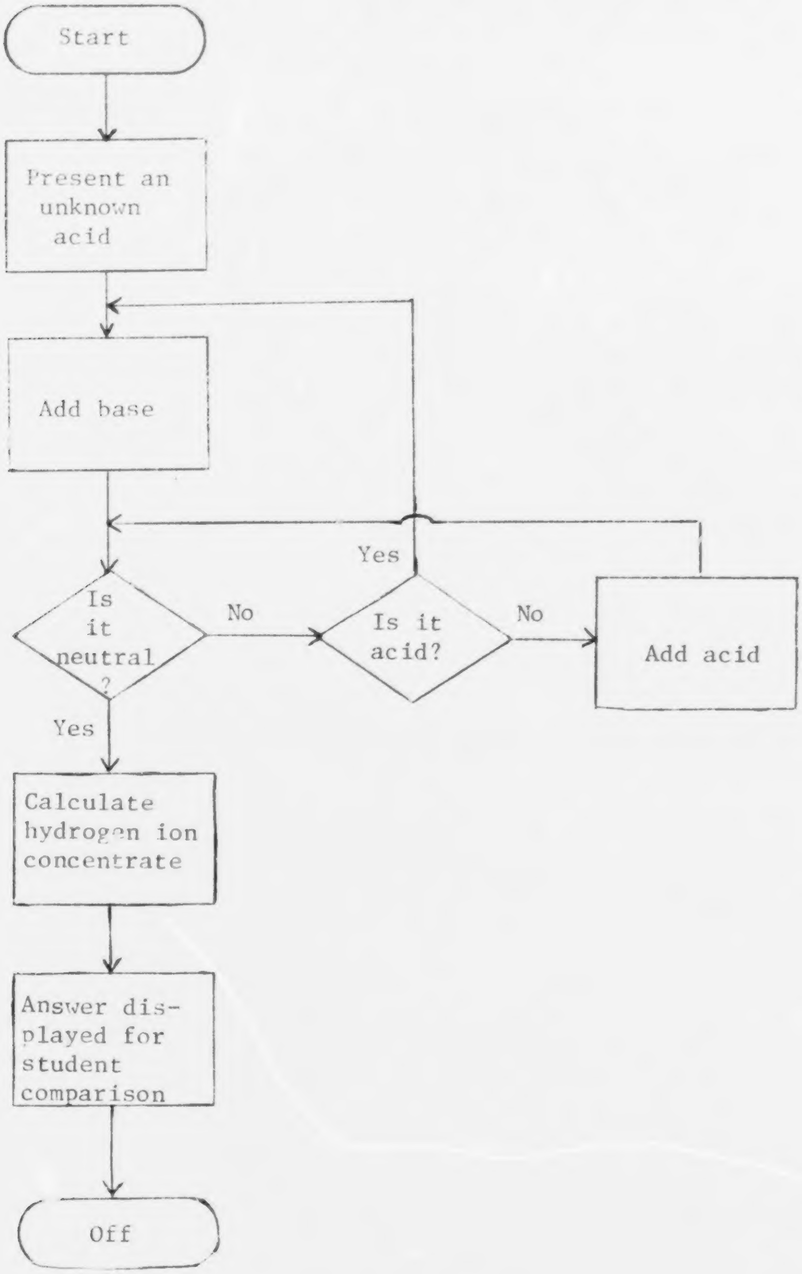
The student, interacting with the IBM 1510 Instructional Display and light pen, is given a simulation of an acid of unknown strength. He then selects an amount of base he wishes to add, and the solution is titrated. The result of the titration is returned to the student in the form of either an acid, base, or neutral. If it remains acidic, the student can add more base. If the converse is true, he back-titrates. When finally the solution becomes neutralized, the student calculates (using a separate calculation mode) the hydrogen ion concentrate present within the unknown solution.

This simulation was designed, authored, and programmed into APL by John M. Boblick.

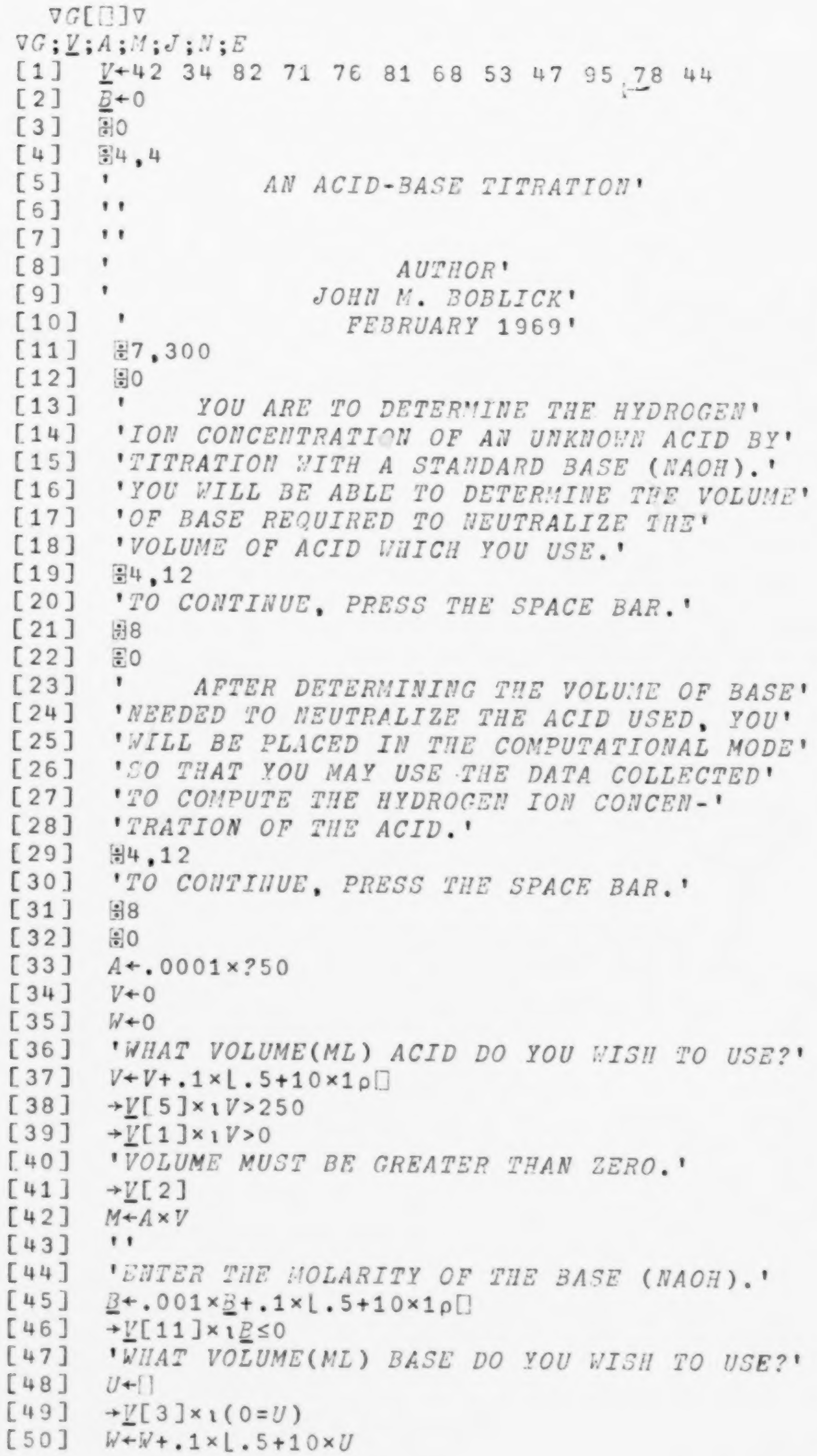
Terminal Objective

Given an acid of unknown strength and the ability to neutralize this solution (by adding base or acid), the student determines the amount of hydrogen ion concentrate present in the unknown solution.

ACID-BASE TITRATION - INSTRUCTIONAL STRATEGY


Start
Present an unknown acid
Add base
Is it neutral?
No
Yes
Is it acid?
Yes
No
Add acid
Calculate hydrogen ion concentrate
Answer displayed for student comparison
Off

Computer Program Printout



```
  ∇G[⎕]∇
∇G;V̲;A;M;J;N;E
[1]   V̲←42 34 82 71 76 81 68 53 47 95 78 44
[2]   B̲←0
[3]   ⌹0
[4]   ⌹4,4
[5]   '         AN ACID-BASE TITRATION'
[6]   ''
[7]   ''
[8]   '                   AUTHOR'
[9]   '              JOHN M. BOBLICK'
[10]   '               FEBRUARY 1969'
[11]  ⌹7,300
[12]  ⌹0
[13]  '    YOU ARE TO DETERMINE THE HYDROGEN'
[14]  'ION CONCENTRATION OF AN UNKNOWN ACID BY'
[15]  'TITRATION WITH A STANDARD BASE (NAOH).'
[16]  'YOU WILL BE ABLE TO DETERMINE THE VOLUME'
[17]  'OF BASE REQUIRED TO NEUTRALIZE THE'
[18]  'VOLUME OF ACID WHICH YOU USE.'
[19]  ⌹4,12
[20]  'TO CONTINUE, PRESS THE SPACE BAR.'
[21]  ⌹8
[22]  ⌹0
[23]  '    AFTER DETERMINING THE VOLUME OF BASE'
[24]  'NEEDED TO NEUTRALIZE THE ACID USED, YOU'
[25]  'WILL BE PLACED IN THE COMPUTATIONAL MODE'
[26]  'SO THAT YOU MAY USE THE DATA COLLECTED'
[27]  'TO COMPUTE THE HYDROGEN ION CONCEN-'
[28]  'TRATION OF THE ACID.'
[29]  ⌹4,12
[30]  'TO CONTINUE, PRESS THE SPACE BAR.'
[31]  ⌹8
[32]  ⌹0
[33]  A←.0001×?50
[34]  V←0
[35]  W←0
[36]  'WHAT VOLUME(ML) ACID DO YOU WISH TO USE?'
[37]  V←V+.1×⌊.5+10×1ρ⎕
[38]  →V̲[5]×⍳V>250
[39]  →V̲[1]×⍳V>0
[40]  'VOLUME MUST BE GREATER THAN ZERO.'
[41]  →V̲[2]
[42]  M←A×V
[43]  ''
[44]  'ENTER THE MOLARITY OF THE BASE (NAOH).'
[45]  B̲←.001×B̲+.1×⌊.5+10×1ρ⎕
[46]  →V̲[11]×⍳B̲≤0
[47]  'WHAT VOLUME(ML) BASE DO YOU WISH TO USE?'
[48]  U←⎕
[49]  →V̲[3]×⍳(0=U)
[50]  W←W+.1×⌊.5+10×U
```

```
[51]   →V[4]×⍳W>50
[52]   N←B×W
[53]   J←N+V
[54]   →V[5]×⍳J>250
[55]   E←M-N
[56]   →V[6]×⍳E=0
[57]   →V[7]×⍳E>0
[58]   'SOLUTION IS BASIC. YOU HAVE PASSED THE'
[59]   'END POINT. YOU MUST BACK-TITRATE BY'
[60]   'ADDING MORE ACID.'
[61]   ''
[62]   'WHAT VOLUME(ML) ACID DO YOU WISH TO ADD?'
[63]   X←⎕
[64]   →V[3]×⍳(0=X)
[65]   V←V+.1×⌊.5+10×X
[66]   M←A×V
[67]   →V[8]
[68]   'FOR ';W;' ML BASE ADDED, THE SOLUTION IS'
[69]   'ACIDIC.  ADD MORE BASE.'
[70]   →V[9]
[71]   ⍠0
[72]   '50 ML BASE DELIVERED, BURETTE IS EMPTY.'
[73]   'TRY AGAIN. USE A SMALLER SAMPLE OF THE'
[74]   'ACID OR A BASE OF GREATER STRENGTH.'
[75]   →V[2]
[76]   'YOUR FLASK IS OVERFLOWING !'
[77]   →V[10]
[78]   'MOLARITY MUST BE GREATER THAN ZERO.'
[79]   →V[12]
[80]   ⍠0
[81]   'THE SOLUTION HAS BEEN NEUTRALIZED.'
[82]   ⍠0
[83]   'YOUR TITRATION RECORD IS AS FOLLOWS:'
[84]   'ML ACID USED =  ';V
[85]   'ML BASE USED =  ';W
[86]   'MOLARITY OF BASE =  ';B×1000
[87]   ''
[88]   'TO CALCULATE THE HYDROGEN ION CONCEN-'
[89]   'TRATION OF THE ACID, SIGNAL ATTENTION;'
[90]   'TO CONTINUE, ENTER →92.'
[91]   ⍠7,18000
[92]   'THE HYDROGEN ION CONCENTRATION IS '
[93]   A×1000;' MOLES/LITER.'
[94]   ''
[95]   'WHEN YOU START AGAIN, YOU WILL HAVE A'
[96]   'NEW ACID TO WORK WITH.'
  ∇
[97]
```

308

Sample Student Interaction

```
  G
          AN ACID-BASE TITRATION


                  AUTHOR
             JOHN M. BOBLICK
              FEBRUARY 1969
    YOU ARE TO DETERMINE THE HYDROGEN
ION CONCENTRATION OF AN UNKNOWN ACID BY
TITRATION WITH A STANDARD BASE (NAOH).
YOU WILL BE ABLE TO DETERMINE THE VOLUME
OF BASE REQUIRED TO NEUTRALIZE THE
VOLUME OF ACID WHICH YOU USE.
TO CONTINUE, PRESS THE SPACE BAR.
    AFTER DETERMINING THE VOLUME OF BASE
NEEDED TO NEUTRALIZE THE ACID USED, YOU
WILL BE PLACED IN THE COMPUTATIONAL MODE
SO THAT YOU MAY USE THE DATA COLLECTED
TO COMPUTE THE HYDROGEN ION CONCEN-
TRATION OF THE ACID.
TO CONTINUE, PRESS THE SPACE BAR.
WHAT VOLUME(ML) ACID DO YOU WISH TO USE?
⊔:
  50

ENTER THE MOLARITY OF THE BASE (NAOH).
⊔:
  50
WHAT VOLUME(ML) BASE DO YOU WISH TO USE?
⊔:
  50
SOLUTION IS BASIC. YOU HAVE PASSED THE
END POINT. YOU MUST BACK-TITRATE BY
ADDING MORE ACID.

WHAT VOLUME(ML) ACID DO YOU WISH TO ADD?
⊔:
  100
SOLUTION IS BASIC. YOU HAVE PASSED THE
END POINT. YOU MUST BACK-TITRATE BY
ADDING MORE ACID.

WHAT VOLUME(ML) ACID DO YOU WISH TO ADD?
⊔:
  100
YOUR FLASK IS OVERFLOWING !
WHEN YOU START AGAIN, YOU WILL HAVE A
NEW ACID TO WORK WITH.
```

Comments

Student usage of this program began during the fall semester of 1969. Validation data has not been collected.

e. THE GAS LAWS

Assessment of Need

The study of the behavior of gases has been a fundamental part of high school chemistry courses for many years. Unfortunately, most students must approach this topic without access to reliable laboratory equipment which would enable them, through experimentation, to determine the relationships among the volume, temperature, and pressure of a gas. To provide the means by which the high school chemistry student could investigate the behavior of an ideal gas, a computer-based simulation was devised.

Description of the Program

The techniques of simulation and drill and practice have been combined in a series of programs. These programs enable the student to "discover" the basic relationships between the properties of gases, as stated in Boyle's Law, Charles' Law, and the Temperature Pressure Relationships. In addition, this MIP offers practice in solving problems of the type initially encountered in the study of gases. The student interacts with the 1510 Instructional Display Unit and the 1518 Image Projector.

Designed by John M. Boblick, the program was written and coded into APL by the author early in 1970.

Terminal Objective

The student solves problems of volume-temperature-pressure relationships by applying the general gas law.

Entering Behaviors

The student:

1. Expresses temperature in the Celsius scale (centigrade).
2. Expresses volume using metric units (liters and milliliters).
3. Defines direct and inverse proportionality.
4. Solves an equation of the form

$$\frac{P.V}{T} = \frac{P_2V_2}{T_2}$$

when given values for three variables.

Enabling Objectives

The student:

1. Defines pressure as the force exerted per unit area of surface.
2. Expresses pressure in the proper units: mm of mercury and atmospheres.

3. Defines the relationship between pressure units (1 atmosphere = 760 mm of mercury).

4. Converts a given temperature, expressed in the Celsius scale, to the Kelvin scale (by adding 273° to the Celsius temperature) and vice versa.

5. Defines standard conditions (STP) as a temperature of 273° Kelvin (0° Celsius) and a pressure of 760 mm of mercury (1 atmosphere).

6. Interprets the cause of gas pressure in terms of molecular collisions.

7. Relates the pressure of a gas to the number of gas molecules present.

8. States Boyle's Law as: At a constant temperature, the volume of a gas varies inversely with the pressure exerted.

9. States Charles' Law as: At a constant pressure, the volume of a gas varies directly with its temperature (expressed in the Kelvin scale).

10. States the rule: At a given volume, the pressure of a gas varies directly with its Kelvin temperature.

11. Solves problems involving pressure-volume relationships by applying Boyle's Law in the forms:

$$P_1V_1 = P_2V_2 \text{ or } PV = K$$

12. Solves problems involving temperature-volume relationships by applying Charles' Law in the forms:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } \frac{V}{T} = K$$

13. Solves problems involving pressure-temperature relationships expressed in the forms:

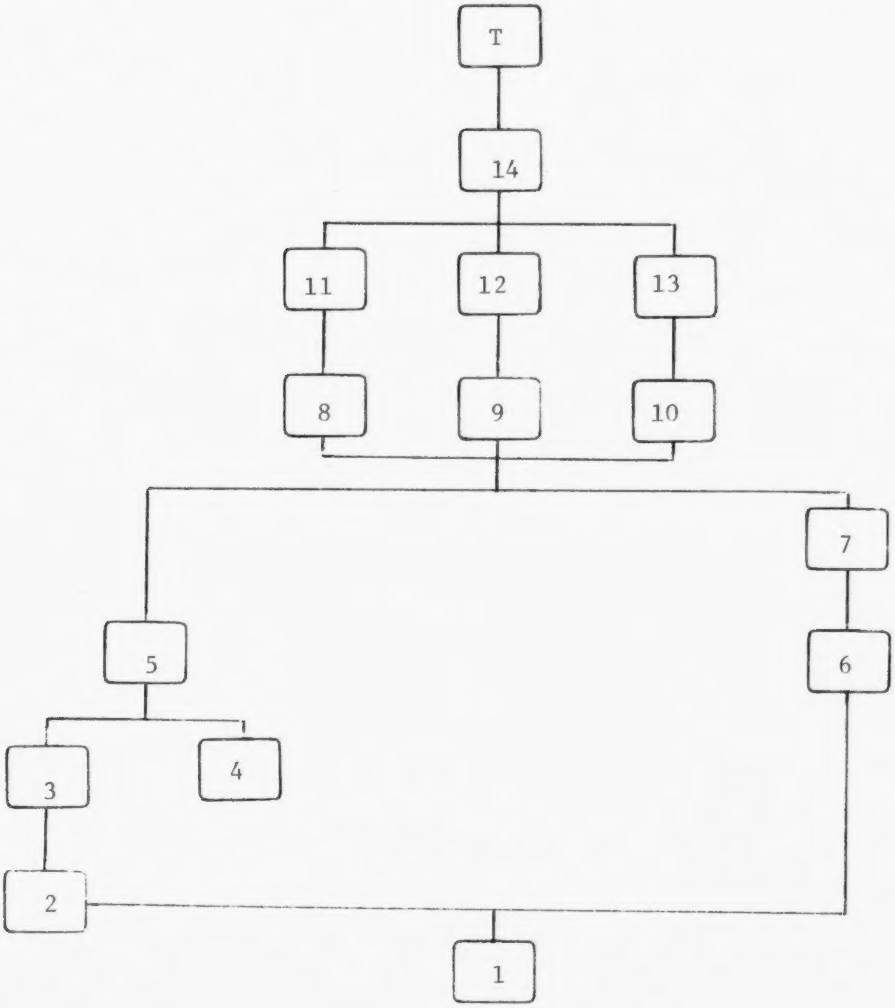
$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \text{ or } \frac{P}{T} = K$$

14. States the general gas law in the forms:

$$\frac{P_1V_1}{T_2} = \frac{P_2V_2}{T_2} \text{ or } \frac{PV}{T} = K$$

THE GAS LAWS

HIERARCHY


T
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1

Pretest and Posttest

THE GAS LAWS

Place the letter of the correct answer in the space provided at the left.

________1. The volume of a gas is:

A. directly proportional to its pressure.
B. inversely proportional to its pressure.
C. not related to its pressure.
D. I don't know.

________2. Decreasing the pressure of a gas will cause its volume to:

A. increase.
B. decrease.
C. remain the same.
D. I don't know.

________3. Twenty-five liters of a gas changes in pressure from 67 mm Hg to 149 mm Hg. The new volume is ____ liters.

A. 25 x 149 ÷ 67
B. 149 x 67 ÷ 25
C. 25 x 67 x 149
D. 25 x 67 ÷ 149
E. I don't know.

________4. The volume of a gas is:

A. directly proportional to its temperature.
B. inversely proportional to its temperature.
C. not related to its temperature.
D. I don't know.

________5. Increasing the temperature of a gas will cause its volume to:

A. increase.
B. decrease.
C. remain the same.
D. I don't know.

________6. Thirty-four liters of a gas changes in temperature from 170° k to 620° k. The new volume is ____ liters.

A. 34 x 170 x 620
B. 34 x 170 ÷ 620
C. 34 x 620 ÷ 170
D. 170 x 620 ÷ 34
E. I don't know.

7. The pressure of a gas is:

   A. directly proportional to its temperature.
   B. inversely proportional to its temperature.
   C. not related to its temperature.
   D. I don't know.

8. Decreasing the temperature of a gas will cause its pressure to:

   A. increase.
   B. decrease.
   C. remain the same.
   D. I don't know.

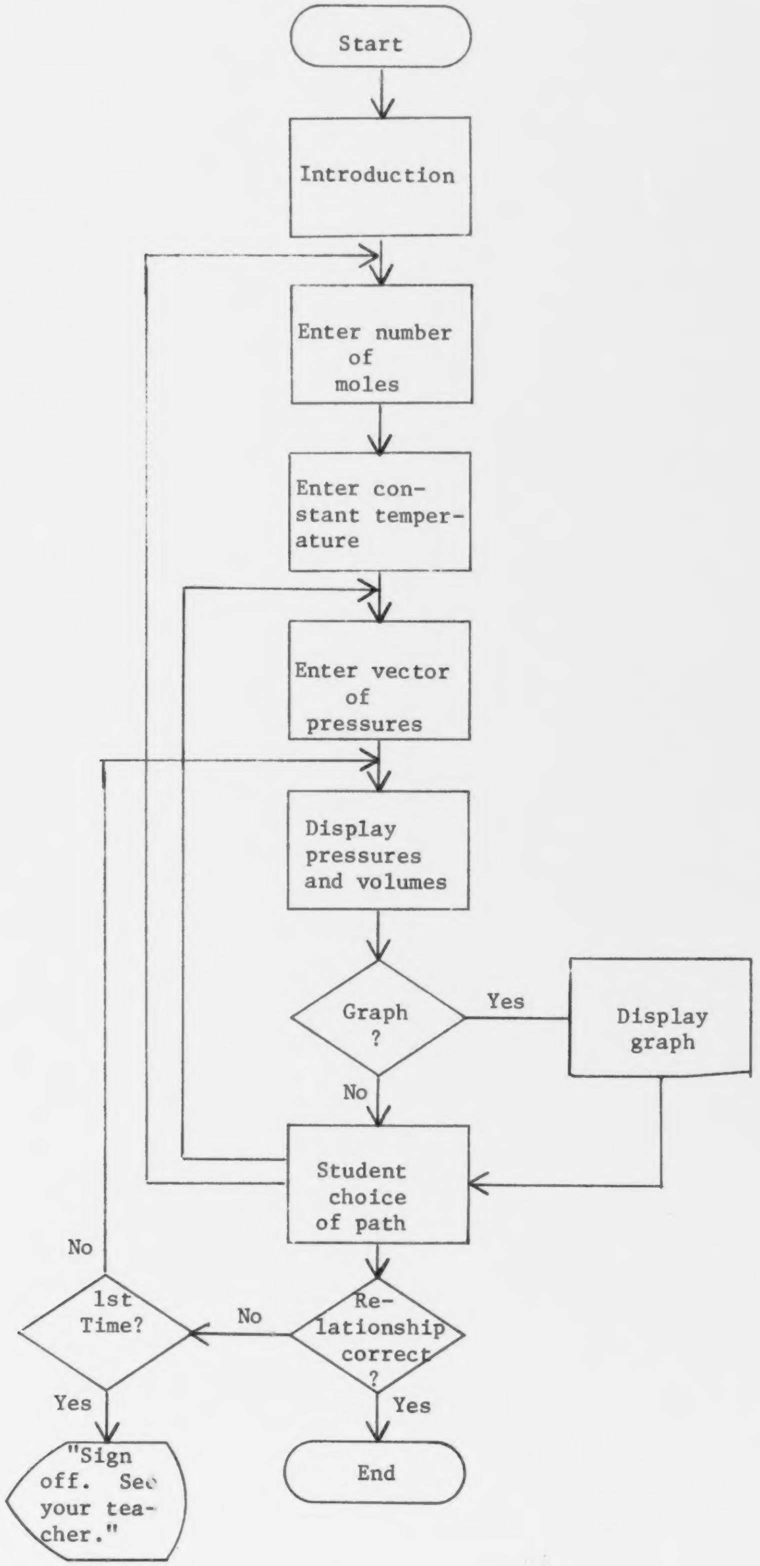
9. A gas with a pressure of 540 mm Hg changes temperature from 350 °k to 620 °k. The new pressure is ____mm Hg.

   A. 540 x 620 ÷ 350
   B. 620 x 350 ÷ 540
   C. 540 x 350 ÷ 620
   D. 540 x 350 x 620
   E. I don't know.

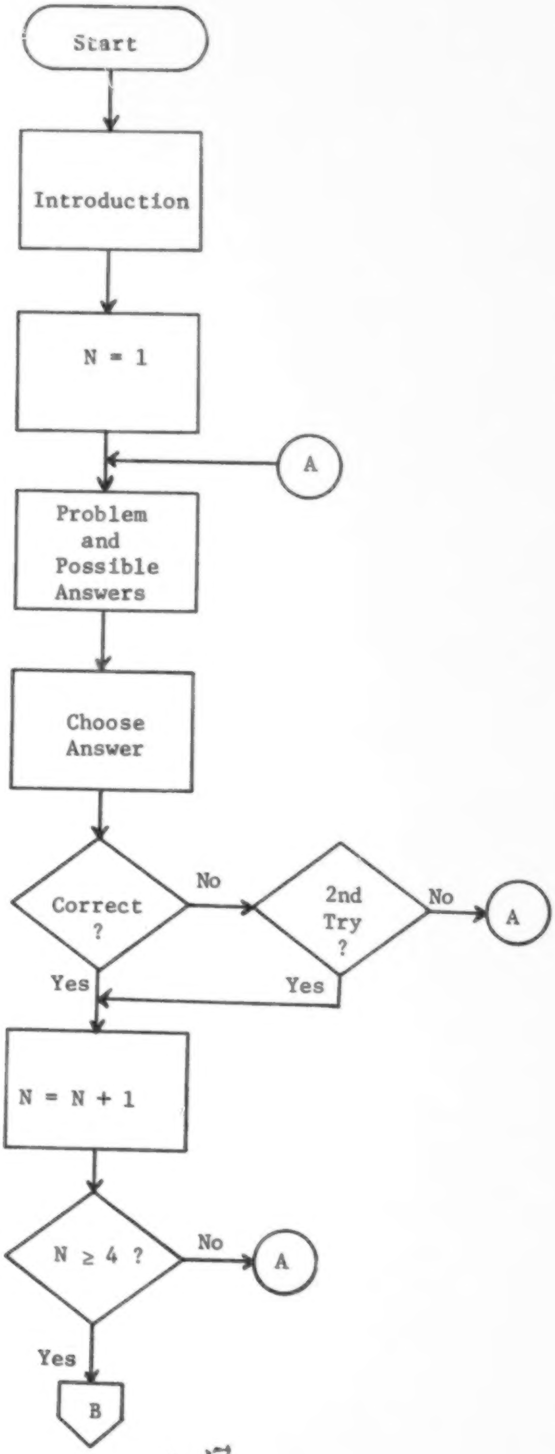
10. A supplier of helium gas wants to increase the amount of gas which he can place in the shipping containers. He should:

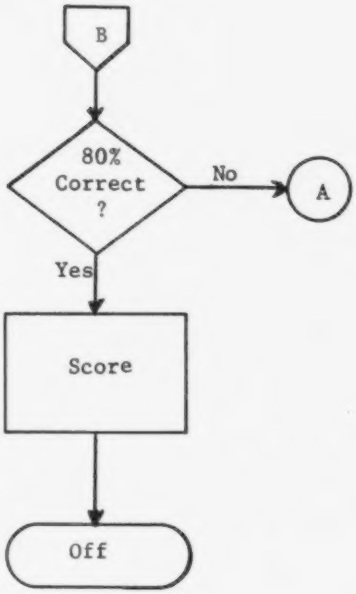
   A. decrease the pressure and decrease the temperature.
   B. decrease the pressure and increase the temperature.
   C. increase the pressure and increase the temperature.
   D. increase the pressure and decrease the temperature.
   E. I don't know.

THE GAS LAWS - SIMULATIONS - INSTRUCTIONAL STRATEGY


Start
Introduction
Enter number of moles
Enter constant temperature
Enter vector of pressures
Display pressures and volumes
Graph ?
Yes
Display graph
No
Student choice of path
No
1st Time?
No
Relationship correct ?
Yes
Yes
"Sign off. See your teacher."
End

THE GAS LAWS - PROBLEMS - INSTRUCTIONAL STRATEGY


Start
Introduction
N = 1
A
Problem and Possible Answers
Choose Answer
Correct ?
No
2nd Try ?
No
A
Yes
Yes
N = N + 1
N ≥ 4 ?
No
A
Yes
B


B
80% Correct ?
No
A
Yes
Score
Off

Computer Program Printout

```
∇B̲[⎕]∇
∇B̲;T̲;T;N;P;G;V;V̲;A;A̲;Z;Z̲
[1]   ⌹0
[2]   ⌹4,4
[3]   'BOYLE''S LAW'
[4]   'PRESSURE -- VOLUME RELATIONSHIPS'
[5]   ⌹4,8
[6]   'AUTHOR  JOHN M. BOBLICK'
[7]   'DECEMBER 1969'
[8]   ⌹7,300
[9]   T̲←0
[10]   ⌹0
[11]   'AT THE END OF THIS PROGRAM YOU WILL BE'
[12]   'ABLE TO EXPRESS THE RELATIONSHIP BETWEEN'
[13]   'THE VOLUME AND THE PRESSURE OF A GAS.'
[14]   ⌹7,600
[15]   ⌹4,6
[16]   'IN THIS PROGRAM YOU WILL USE NITROGEN'
[17]   'GAS.  HOWEVER, THE BEHAVIOR EXHIBITED'
[18]   'BY THE NITROGEN IS COMMON TO ALL GASES.'
[19]   ⌹7,900
[20]   ⌹0
[21]   'ENTER THE NUMBER OF MOLES OF NITROGEN'
[22]   'GAS WHICH YOU WISH TO USE.'
[23]   N←⎕
[24]   'THE TEMPERATURE OF THE GAS MUST BE'
[25]   'CONSTANT IN THIS EXPERIMENT.  ENTER'
[26]   'THE TEMPERATURE (IN ∘K) OF THE GAS.'
[27]   T←⎕
[28]   ⌹0
[29]   'ENTER A SET OF VALUES FOR THE PRESSURE'
[30]   'OF THE GAS, EXPRESSED IN MM HG.'
[31]   P←⎕
[32]   V←(62.36×N×T)÷P
[33]   ⌹0
[34]   'P̲R̲E̲S̲S̲U̲R̲E̲ V̲O̲L̲U̲M̲E̲(L̲I̲T̲E̲R̲S̲)'
[35]   ⍉((2,⍴P)⍴P,V)
[36]   'PRESS THE SPACE BAR TO CONTINUE.'
[37]   ⌹8
[38]   ⌹0
[39]   'IF YOU WISH TO SEE A GRAPH OF V VS P,'
[40]   'ENTER 1.  IF YOU DO NOT WISH TO SEE THE'
[41]   'GRAPH, ENTER 0 (ZERO).'
[42]   G←⎕
[43]   →(G=0)/47
[44]   Z←(⌊/P),⌈/P
[45]   V̲←(⌊/V),⌈/V
[46]   (Z,V̲)⌹P,V
[47]   ⌹0
[48]   'WHAT DO YOU WISH TO DO NEXT ?'
[49]   ⌹4,2
[50]   '1 - GO TO THE QUIZ.'
```

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[51]  '2 - ENTER A NEW SET OF PRESSURES.'
[52]  '3 - START AGAIN FROM THE BEGINNING.'
[53]  '4 - SEEK YOUR TEACHER''S HELP.'
[54]  'ENTER THE NUMBER OF YOUR ANSWER.'
[55]  A←⎕
[56]  →((A=1),(A=2),(A=3),(A=4))/61 28 10 59
[57]  'ENTER A NUMBER FROM 1 TO 4.'
[58]  →54
[59]  'SIGN OFF NOW.'
[60]  →0,ρ⍞←'SEE YOUR TEACHER FOR HELP.'
[61]  ⌹0
[62]  'HERE''S YOUR QUICKIE QUIZ.'
[63]  ⌹7,180
[64]  ⌹0
[65]  'INDICATE THE RELATIONSHIP BETWEEN THE'
[66]  'VOLUME AND THE PRESSURE OF THE'
[67]  'NITROGEN GAS.'
[68]  '1 - VOLUME IS DIRECTLY PROPORTIONAL TO'
[69]  '    THE PRESSURE.'
[70]  '2 - VOLUME IS INVERSELY PROPORTIONAL TO'
[71]  '    THE PRESSURE.'
[72]  '3 - VOLUME IS NOT RELATED TO PRESSURE.'
[73]  '4 - I HAVE NO IDEA WHICH OF THE ABOVE'
[74]  '    IS CORRECT.'
[75]  'ENTER THE NUMBER OF YOUR ANSWER.'
[76]  A̲←⎕
[77]  →(((A̲=1)∧(T̲≥2)),((A̲=1)∧(T̲<2)),(A̲=2),((A̲=3)∧(T̲≥2)),((A̲=3)∧(T̲<2)),(A̲=
[78]  →75,ρ⍞←'ENTER A NUMBER FROM 1 TO 4.'
[79]  ⌹0
[80]  'ARE YOU SURE ?  LOOK AGAIN.'
[81]  'HOW DOES THE VOLUME CHANGE AS THE'
[82]  'PRESSURE INCREASES ?'
[83]  ⌹7,600
[84]  →33,T̲←T̲+1
[85]  ⌹0
[86]  'THAT''S RIGHT ! THIS RELATIONSHIP, KNOWN'
[87]  'AS BOYLE''S LAW, IS STATED AS: AT A CON-'
[88]  'STANT TEMPERATURE, THE VOLUME OF A GAS'
[89]  'IS INVERSELY PROPORTIONAL TO ITS PRES-'
[90]  'SURE.'
[91]  ''
[92]  'HAVING ATTAINED THE OBJECTIVE OF THIS'
[93]  'PROGRAM, YOU MAY NOW INVESTIGATE ANOTHER'
[94]  'PROPERTY OF GASES.'
 ∇
[95]
```

```
  ∇B[⎕]∇
∇B;T;X;A;A̲;R;Q;W;C̲
[1]  ⌹0
[2]  ⌹4,4
[3]  'BOYLE''S LAW'
[4]  'PRESSURE - VOLUME RELATIONSHIPS'
[5]  ⌹4,8
[6]  'AUTHOR  JOHN H. BOBLICK'
[7]  'NOVEMBER 1969'
[8]  ⌹7,300
[9]  C̲←W←Q←0
[10]  ⌹0
[11]  'IN EACH OF THESE PROBLEMS THE'
[12]  'TEMPERATURE REMAINS CONSTANT.'
[13]  ⌹7,300
[14]  T←0
[15]  X←10×3?80
[16]  A←?4
[17]  Q←Q+1
[18]  ⌹0
[19]  X[1];' LITERS OF A GAS CHANGES IN PRESSURE'
[20]  'FROM ';X[2];'MM HG TO ';X[3];'MM HG.'
[21]  'THE NEW VOLUME IS:'
[22]  →((A=2),(A=3),(A=4))/28 33 38
[23]  '1-  ';X[1];'×';X[2];'÷';X[3]
[24]  '2-  ';X[1];'×';X[3];'÷';X[2]
[25]  '3-  ';X[1];'×';X[2];'×';X[3]
[26]  '4-  ';X[2];'×';X[3];'÷';X[1]
[27]  →42
[28]  '1-  ';X[2];'×';X[3];'÷';X[1]
[29]  '2-  ';X[1];'×';X[2];'÷';X[3]
[30]  '3-  ';X[1];'×';X[3];'÷';X[2]
[31]  '4-  ';X[1];'×';X[2];'×';X[3]
[32]  →42
[33]  '1-  ';X[1];'×';X[2];'×';X[3]
[34]  '2-  ';X[2];'×';X[3];'÷';X[1]
[35]  '3-  ';X[1];'×';X[2];'÷';X[3]
[36]  '4-  ';X[1];'×';X[3];'÷';X[2]
[37]  →42
[38]  '1-  ';X[1];'×';X[3];'÷';X[2]
[39]  '2-  ';X[1];'×';X[2];'×';X[3]
[40]  '3-  ';X[2];'×';X[3];'÷';X[1]
[41]  '4-  ';X[1];'×';X[2];'÷';X[3]
[42]  'ENTER THE NUMBER OF YOUR ANSWER.'
[43]  A̲←⎕
[44]  T←T+1
[45]  →(((A̲≠A)∧(T<2)),((A̲≠A)∧(T≥2)),((A̲≠A)∧(A̲>4)))/49 52 67
[46]  'CORRECT !'
[47]  ⌹7,300
[48]  →55,C̲←C̲+1
[49]  'THAT''S NOT CORRECT. TRY AGAIN.'
[50]  ⌹7,300
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```
[51]   →18,W←W+1
[52]   'THE CORRECT ANSWER IS ';A
[53]   W←W+1
[54]   ⌶7,300
[55]   ⌶0
[56]   'THE NEW VOLUME EQUALS ';X[1]×X[2]÷X[3];' LITERS.'
[57]   'DO YOU WISH TO TRY ANOTHER PROBLEM ?'
[58]   'IF YES, ENTER 1;IF NO, ENTER 0(ZERO).'
[59]   R←⎕
[60]   →10×⍳(R=1)
[61]   'YOUR PERFORMANCE ON THIS DRILL IS:'
[62]   'PROBLEMS TRIED          ';Q
[63]   'CORRECT ANSWERS         ';C̲
[64]   'WRONG ANSWERS           ';W
[65]   'PER CENT CORRECT        ';100×C̲÷(C̲+W)
[66]   →0
[67]   'ENTER THE NUMBER (1 2 3 4) OF THE ANSWER'
[68]   →43
 ∇
[69]
```

Sample Student Interaction

```
  B
BOYLE'S LAW
PRESSURE -- VOLUME RELATIONSHIPS
AUTHOR  JOHN M. BOBLICK
DECEMBER 1969
AT THE END OF THIS PROGRAM YOU WILL BE
ABLE TO EXPRESS THE RELATIONSHIP BETWEEN
THE VOLUME AND THE PRESSURE OF A GAS.
IN THIS PROGRAM YOU WILL USE NITROGEN
GAS.  HOWEVER, THE BEHAVIOR EXHIBITED
BY THE NITROGEN IS COMMON TO ALL GASES.
ENTER THE NUMBER OF MOLES OF NITROGEN
GAS WHICH YOU WISH TO USE.
⎕:
  2.0
THE TEMPERATURE OF THE GAS MUST BE
CONSTANT IN THIS EXPERIMENT.  ENTER
THE TEMPERATURE (IN °K) OF THE GAS.
⎕:
  273
ENTER A SET OF VALUES FOR THE PRESSURE
OF THE GAS, EXPRESSED IN MM HG.
⎕:
  100 200 300 400
PRESSURE VOLUME(LITERS)

 100       340.486
 200       170.243
 300       113.495
 400        85.1214
PRESSURE THE SPACE BAR TO CONTINUE.
IF YOU WISH TO SEE A GRAPH OF V VS P,
ENTER 1.  IF YOU DO NOT WISH TO SEE THE
GRAPH, ENTER 0 (ZERO).
⎕:
   1

 3.40+
     |
     |
 2.77+
     |
     |
 2.13+
     |
     |
 1.49+
     |
     |
 0.85+                             °
      +-----+-----+-----+-----+-----+-
     1.00  1.60  2.20  2.80  3.40  4.00
   X←X×10* 02          Y←Y×10* 02
WHAT DO YOU WISH TO DO NEXT ?
1 - GO TO THE QUIZ.
2 - ENTER A NEW SET OF PRESSURES.
3 - START AGAIN FROM THE BEGINNING.
4 - SEEK YOUR TEACHER'S HELP.
ENTER THE NUMBER OF YOUR ANSWER.
⎕:
  4
SIGN OFF NOW.
SEE YOUR TEACHER FOR HELP.
```

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  B
BOYLE'S LAW
PRESSURE - VOLUME RELATIONSHIPS
AUTHOR  JOHN M. BOBLICK
NOVEMBER 1969
IN EACH OF THESE PROBLEMS THE
TEMPERATURE REMAINS CONSTANT.
570 LITERS OF A GAS CHANGES IN PRESSURE
FROM 190MM HG TO 220MM HG.
THE NEW VOLUME IS:
1-  190×220÷570
2-  570×190÷220
3-  570×220÷190
4-  570×190×220
ENTER THE NUMBER OF YOUR ANSWER.
⎕:
  2
CORRECT !
THE NEW VOLUME EQUALS  492.273 LITERS.
DO YOU WISH TO TRY ANOTHER PROBLEM ?
IF YES, ENTER 1;IF NO, ENTER 0(ZERO).
⎕:
  1
IN EACH OF THESE PROBLEMS THE
TEMPERATURE REMAINS CONSTANT.
250 LITERS OF A GAS CHANGES IN PRESSURE
FROM 550MM HG TO 510MM HG.
THE NEW VOLUME IS:
1-  250×550÷510
2-  250×510÷550
3-  250×550×510
4-  550×510÷250
ENTER THE NUMBER OF YOUR ANSWER.
⎕:
  3
THAT'S NOT CORRECT. TRY AGAIN.
250 LITERS OF A GAS CHANGES IN PRESSURE
FROM 550MM HG TO 510MM HG.
THE NEW VOLUME IS:
1-  250×550÷510
2-  250×510÷550
3-  250×550×510
4-  550×510÷250
ENTER THE NUMBER OF YOUR ANSWER.
⎕:
  1
CORRECT !
THE NEW VOLUME EQUALS  269.608 LITERS.
DO YOU WISH TO TRY ANOTHER PROBLEM ?
IF YES, ENTER 1;IF NO, ENTER 0(ZERO).
⎕:
  0
YOUR PERFORMANCE ON THIS DRILL IS:
PROBLEMS TRIED        2
CORRECT ANSWERS       2
WRONG ANSWERS         1
PER CENT CORRECT       66.6667
```

Comment

This program was validated in the spring of 1970 with ten chemistry students who had not mastered the terminal objective following regular classroom instruction.

f. CONSTRUCTION OF A LENS

Assessment of Need

The refraction of light is a concept encountered by all high school physics students. When studying this characteristic behavior of light, the functioning of a lens is often used as a practical example of refraction. However, the refraction of light passing through the lens is usually described in a superficial way, and the relationship between lens function and refraction of light is not always clearly explained to the student.

Description of the Program

This tutorial program, written in COURSEWRITER II, attempts to relate lens function to refraction through the use of graphic representations of lens structure on the CRT screen. The student observes the change in the path of light rays as they pass through a block of glass which itself changes from a rectangular solid to a double convex lens. By observing the path of light rays in each stage of the lens construction, the student is able to see clearly that the change in the path of the light is produced by refraction as the light enters and leaves the lens.

This program was designed and authored by John M. Boblick in August, 1969, and programmed by Chris Eshleman. It utilizes the 1510 Instructional Display Unit with light pen and student flipbook.

Terminal Objective

The student uses the principal ray method to draw the path of a light ray entering the lens parallel to the principal axis of the lens.

Entering Behaviors

The student:

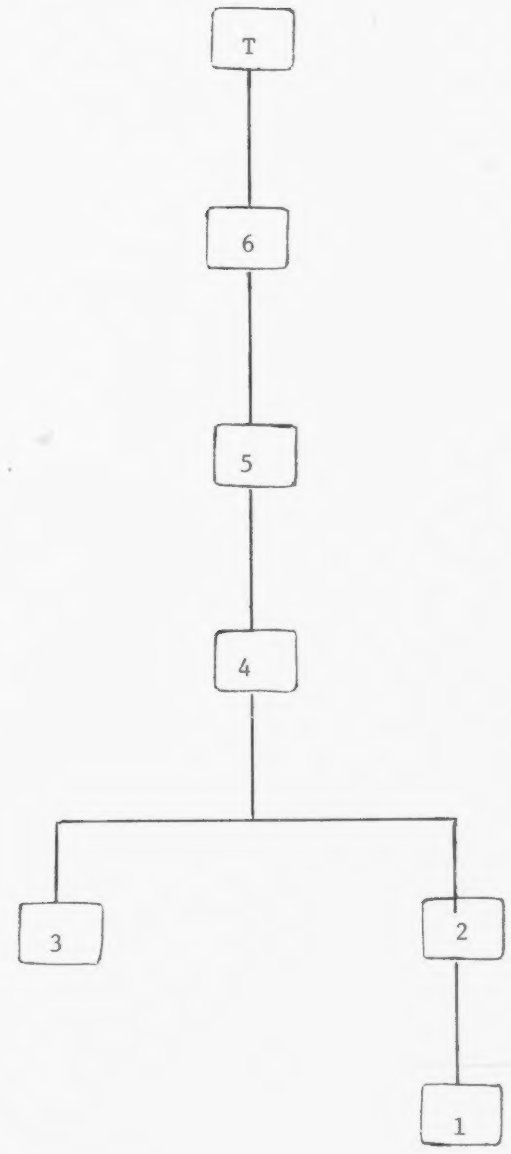
1. Defines ray of light.
2. States that light travels in a straight line.
3. Defines refraction.
4. Identifies the angle of incidence and the angle of refraction when given a diagram of light ray passing from one medium to another.
5. Defines index of refraction.
6. States Snell's Law.
7. Applies Snell's Law to calculate the angle of refraction of a ray of light as it passes from one medium to another.

Enabling Objectives

The student:

1. Describes the effect on the bending of the light ray produced when the angle of incidence is changed.
2. Describes the effect on the bending of the light ray produced when the shape of the lens is changed.
3. Describes the effect on the bending of the light ray produced when the index of refraction of the lens is changed.
4. Relates the changes described in Number 1, 2, and 3 to the refraction of light.
5. Interprets the behavior of light rays passing through a lens as dependent upon the refraction of light as it passes from one medium to another.
6. Demonstrates the bending of light rays as they pass through a double convex lens by drawing the path of the rays.

CONSTRUCTION OF A LENS HIERARCHY



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Comments

The student is introduced to the simplified, principal ray method of describing the path of the light rays. In this way, he is able to interpret the behavior of the lens in terms of the refraction of light and is able to represent this bending of light rays, using a method which is easy for him.

g. THE FORCE BETWEEN CHARGED PARTICLES

Assessment of Need

When beginning his study of static electricity, the high school physics student encounters an experiment designed to help him "discover" Coulomb's Law – the relationship between the separation of electrical charges and the electric force produced by the charges.

Often this experiment takes the form of charging suspended pith balls and measuring the deflections produced at different separations of the spheres. However, the inherent problems of this experiment – the handling of the spheres and the leaking of the electrical charges – are often frustrating. Students sometimes experience difficulty in obtaining complete and valid experimental data.

Description of the Program

The difficulties in obtaining data have been eliminated through the development of a computer simulation of the Coulomb's Experiment. The student not only obtains valid results each time, but he is also permitted to employ a much greater range of charges and separations. For each set of values for the charges and the separations which the student uses, the forces are calculated and displayed with the corresponding separations. In addition, the graph of the force-separation relationship is plotted by the computer system. The time ordinarily used by the student to plot the graph by hand may now be used in the more important aspect of interpreting the graph. He may also repeat the experiment using a wider range of variables to determine whether or not the same relationship exists for all possible separations of the charges. This simulation of a laboratory experiment produces valid results for any set of variables which the student elects to use. In this way, the student is guided toward his "discovery" of Coulomb's Law in a faster, more efficient manner.

This program, written in A PROGRAMMING LANGUAGE by John M. Boblick, utilizes the 1510 Instructional Display. It was completed in the fall of 1969.

Terminal Objectives

The student:

1. States the relationship between the separation of two point charges and the electric force between them.

2. Uses the data generated by the experiment to discover the relationship between electric force and the separation of the charged particles.

3. Employs the plot function of APL to analyze data generated by the experiment.

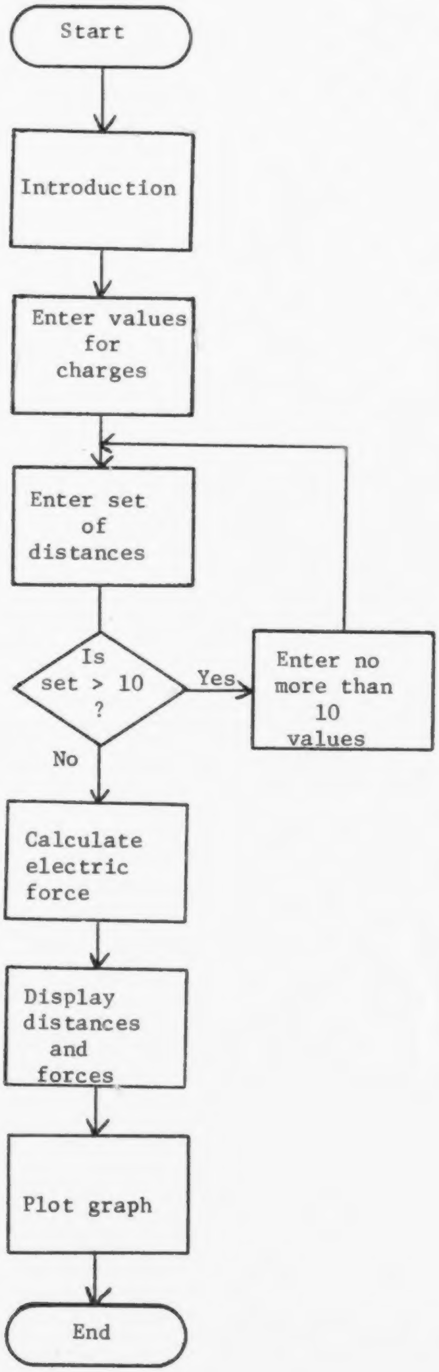
Entering Behaviors

The student:

1. Expresses force, electric charge, and distance in the proper units for the MKS system.
2. Describes the relation between the electric force exerted between particles and the charges on those particles.
3. Identifies a point charge.
4. Given values for two variables, constructs a graph using those variables.
5. Identifies a straight line graph as a representation of a direct proportion between the variables.
6. Identifies a vector as a quantity composed of more than one element.
7. Defines an argument as the value upon which an APL instruction will operate.
8. Defines catentation as the chaining of vectors (or scalars) together to form a vector.

THE FORCE BETWEEN CHARGED PARTICLES

INSTRUCTIONAL STRATEGY


Start
Introduction
Enter values for charges
Enter set of distances
Is set > 10 ?
Yes
Enter no more than 10 values
No
Calculate electric force
Display distances and forces
Plot graph
End

Computer Program Printout

```
   ∇Q[⎕]∇
 ∇Q;R̲;F̲;C;C̲
[1]   ⌹0
[2]   ⌹4,4
[3]   'THE FORCES BETWEEN CHARGED PARTICLES'
[4]   ⌹4,7
[5]   'AUTHOR  JOHN M. BORLICK'
[6]   'MARCH 1969'
[7]   ⌹7,300
[8]   ⌹0
[9]   'THIS LESSON WILL ENABLE YOU TO DISCOVER'
[10]   'THE RELATIONSHIP BETWEEN THE SEPARATION'
[11]   'OF TWO POINT CHARGES AND THE ELECTRIC'
[12]   'FORCE BETWEEN THEM.  AT THE END OF THIS'
[13]   'LESSON YOU WILL BE ASKED TO STATE THAT'
[14]   'RELATIONSHIP.'
[15]   ⌹4,12
[16]   'TO CONTINUE, PRESS THE SPACE BAR.'
[17]   ⌹8
[18]   ⌹0
[19]   'ENTER THE CHARGE (IN COULOMBS) ON Q1.'
[20]   C←⎕
[21]   'ENTER THE CHARGE (IN COULOMBS) ON Q2.'
[22]   C̲←⎕
[23]   'ENTER A SET(5-10) OF DISTANCES (IN M)'
[24]   'BETWEEN THE CHARGES.'
[25]   R←⎕
[26]   →(10≥⍴R)/29
[27]   'ENTER NO MORE THAN 10 VALUES.'
[28]   →25
[29]   F←(C×C̲×8.988E9)÷R*2
[30]   ⌹0
[31]   'THE FORCES (IN NEWTONS) ARE:'
[32]   '          _R̲_             _F̲_'
[33]   ⍉((2,⍴R)⍴R,F)
[34]   ⌹8
[35]   R̲←(⌊/R),⌈/R
[36]   F̲←(⌊/F),⌈/F
[37]   (R̲,F̲)⌹R,F
[38]   ⌹0
[39]   'TO BEGIN AGAIN, ENTER THE LETTER Q.'
 ∇
```

Sample Student Interaction

```
  Q
THE FORCES BETWEEN CHARGED PARTICLES
AUTHOR  JOHN M. BOBLICK
MARCH 1969
THIS LESSON WILL ENABLE YOU TO DISCOVER
THE RELATIONSHIP BETWEEN THE SEPARATION
OF TWO POINT CHARGES AND THE ELECTRIC
FORCE BETWEEN THEM.  AT THE END OF THIS
LESSON YOU WILL BE ASKED TO STATE THAT
RELATIONSHIP.
TO CONTINUE, PRESS THE SPACE BAR.
ENTER THE CHARGE (IN COULOMBS) ON Q1.
⎕:
  .5
ENTER THE CHARGE (IN COULOMBS) ON Q2.
⎕:
  10
ENTER A SET(5-10) OF DISTANCES (IN M)
BETWEEN THE CHARGES.
⎕:
  .1 .15 .2 .3 .4 .5 .6 .7 .8 .9
THE FORCES (IN NEWTONS) ARE:
     _R_          _F_

 1.00000E¯1   4.49400E12
 1.50000E¯1   1.99733E12
 2.00000E¯1   1.12350E12
 3.00000E¯1   4.99333E11
 4.00000E¯1   2.80875E11
 5.00000E¯1   1.79760E11
 6.00000E¯1   1.24833E11
 7.00000E¯1   9.17143E10
 8.00000E¯1   7.02188E10
 9.00000E¯1   5.54815E10

 4.49+ o
     |
     |
 3.38+
     |
     |
 2.27+
     |   o
     |
 1.17+     o
     |
     |         o  o   o
 0.06+                    o   o  o   o
       +-----+-----+-----+-----+-----+-
     1.00  2.60  4.20  5.80  7.40  9.00
    X←X×10*¯01          Y←Y×10* 12
TO BEGIN AGAIN, ENTER THE LETTER Q.
```

```
   X←0 1 2 3 4 5 6 7 8 9 10
   Y←5 4 3 2 1 0 1 2 3 4 5
   Y V̲ X

  5.00+ ∘                             ∘
      |
      |
  3.75+    ∘                       ∘
      |
      |       ∘                 ∘
  2.50+
      |
      |          ∘           ∘
  1.25+
      |             ∘     ∘
      |
  0.00+                ∘
        +-----+-----+-----+-----+-----+-
      0.00  0.20  0.40  0.60  0.80  1.00
    X←X×10* 01          Y←Y×10* 00
```

```
  S
ENTER DATA
⎕:
  64.1 65.0 63.9 64.3 63.5 64.4 64.6

N  = 7
MEAN  =  64.2571
STANDARD DEVIATION  =  0.449943
RANGE  =  63.5 TO 65


  S
ENTER DATA
⎕:
  36.9 36.1 37.0 37.2 37.4 36.7 37.0 36.6 37.2

N  = 9
MEAN  =  36.9
STANDARD DEVIATION  =  0.368179
RANGE  =  36.1 TO  37.4
```

Comments

If a student does not "discover" the relationships from the use of the simulation program, two sets of supplemental instructions are provided. This program has not been validated.

h. MOTION IN THE EARTH'S GRAVITATIONAL FIELD

Assessment of Need

The need for this program was identified by the author John M. Boblick as a result of his classroom experiences.

Description of the Program

This program is adaptable for use in several investigations of motion in which there are two components of the motion acting in different directions. One of these components is the acceleration of gravity; the other can be varied from a constant horizontal velocity to a constant upward velocity.

In each of the cases, the student is given a simplified version of the motion in the earth's gravitational field. The force caused by air resistance has been eliminated, and any changes in gravitational force caused by the vertical movement of the body closer or farther away from the earth's center have been ignored.

In each part of the program, the point on or above the earth's surface from which the projectile is released is assigned the value of zero on the *Y*-axis. This means that a positive value of *Y* is above the release point, and a negative value of *Y* is below the release point.

The student may make up to ten observations of the moving body for any set of speed and direction variables which he selects. In most cases, he will be given a graphic representation of that motion which resembles the data collected using a stroboscopic photographic technique. He is also able to select the time interval between observations.

Through the use of this simulation, the student is able to study the motion of a projectile in more detail than is normally possible in a high school physics laboratory. He also avoids the risk of a collision with the projectile under study.

This program, which utilizes the 1510 Instructional Display Unit, was developed by John M. Boblick in the summer of 1969 and was coded into APL by the author.

Terminal Objectives

The student:

1. Describes the path of a projectile moving through the Earth's gravitational field with an initial velocity which is not parallel to the force exerted by the gravitational field.
2. Describes the path of a projectile moving through the Earth's gravitational field with an initial velocity which is:
    a. Perpendicular to the direction of gravitational acceleration.
    b. At an angle of 1 – 89 degrees above the horizontal.
    c. In the opposite direction of the gravitational acceleration.
3. Identifies the angle above the horizontal which will give the maximum horizontal displacement for a constant initial speed of a projectile.
4. Determines from the data given the horizontal displacement for a selected time interval.
5. Determines from the data given the vertical displacement for a selected time interval.

Entering Behaviors

The student:

1. Distinguishes between speed and velocity.
2. Expresses velocity and acceleration in the units of the MKS system.
3. Defines a vector as having both magnitude and direction.
4. Adds vectors.
5. Identifies the components of a vector in a given direction.
6. Applies the basic rules of kinematics; i.e.:
    a. $v_f = v_i t + a t_i$
    b. $d = v_i t + 1/2\, a t^2$
    c. $v = \frac{d}{t}$

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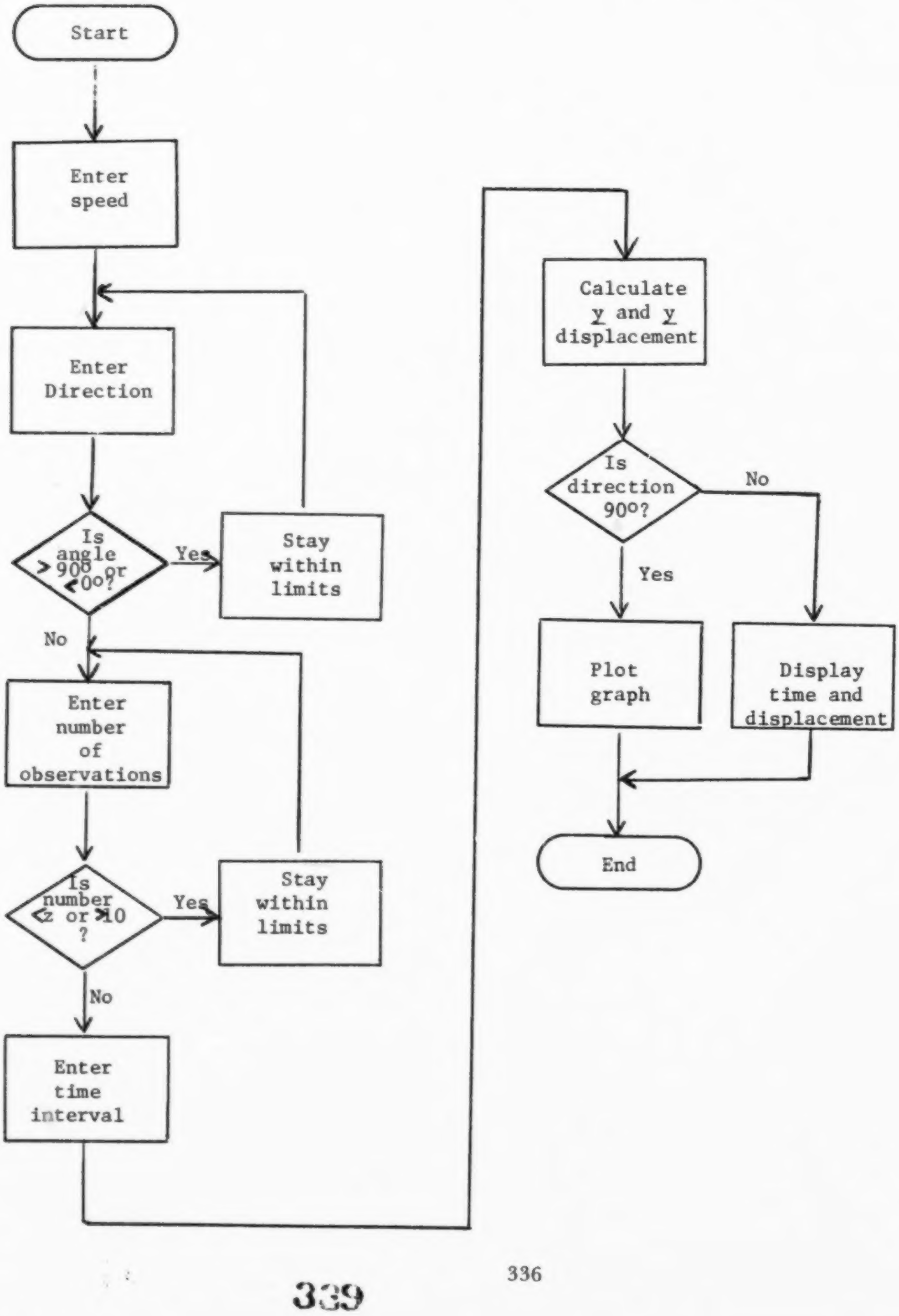
MOTION IN THE EARTH'S GRAVITATIONAL FIELD

INSTRUCTIONAL STRATEGY


Start
Enter speed
Enter Direction
Is angle > 90° or < 0°?
Yes
Stay within limits
No
Enter number of observations
Is number < 2 or > 10 ?
Yes
Stay within limits
No
Enter time interval
Calculate y and y displacement
Is direction 90°?
No
Yes
Plot graph
Display time and displacement
End

Computer Program Printout

```
  ∇P[⎕]∇
∇P;T;H;X;Y;X̲;Y̲;B
[1]   ⌹0
[2]   B←41 32 49 42 59 62 55 64 68 72
[3]   ⌹4,4
[4]   '        MOTION IN THE EARTH''S'
[5]   '         GRAVITATIONAL FIELD'
[6]   ''
[7]   ''
[8]   '                AUTHOR'
[9]   '            JOHN M. BOBLICK'
[10]  '                MAY  1969'
[11]  ⌹7,300
[12]  ⌹0
[13]  '      THIS PROGRAM SIMULATES THE MOTION'
[14]  'OF A BODY IN THE EARTH''S GRAVITATIONAL'
[15]  'FIELD.'
[16]  ⌹4,12
[17]  'TO CONTINUE, PRESS THE SPACE BAR.'
[18]  ⌹8
[19]  ⌹0
[20]  '      IF YOU ENTER THE INITIAL SPEED AND'
[21]  'THE INITIAL DIRECTION OF THE BODY, EX-'
[22]  'PRESSED AS THE ANGLE ABOVE THE HORI-'
[23]  'ZONTAL, A REPRESENTATION OF THE BODY''S'
[24]  'MOTION WILL BE DISPLAYED FOR YOU.'
[25]  ⌹4,12
[26]  'TO CONTINUE, PRESS THE SPACE BAR.'
[27]  ⌹8
[28]  ⌹0
[29]  'ENTER THE INITIAL SPEED (IN M/SEC) OF'
[30]  'THE BODY.'
[31]  S←⎕
[32]  'ENTER THE INITIAL DIRECTION OF THE BODY,'
[33]  'EXPRESSED AS THE ANGLE (IN DEGREES)'
[34]  'ABOVE THE HORIZONTAL. THE LIMITS ARE'
[35]  '0 - 90 DEGREES.'
[36]  D←⎕
[37]  →B[1]×⍳(D≥0)∧(D≤90)
[38]  'PLEASE STAY WITHIN THE STATED LIMITS'
[39]  'OF 0 - 90 DEGREES.'
[40]  →B[2]
[41]  ⌹0
[42]  'ENTER THE NUMBER (2-10) OF OBSERVATIONS'
[43]  'WHICH YOU WISH TO MAKE.'
[44]  O←⎕
[45]  →B[3]×⍳(O≥2)∧(O≤10)
[46]  'PLEASE STAY WITHIN THE STATED LIMITS'
[47]  'OF 2 - 10 OBSERVATIONS.'
[48]  →B[4]
[49]  'ENTER THE TIME INTERVAL (IN SEC)'
[50]  'BETWEEN OBSERVATIONS.'
```

```
[51]  I←T
[52]  ⌹0
[53]  T←I×⍳N
[54]  →(((D=0),(D=90),(((D>0)∧(D<90))))/59 62 55
[55]  H←S×((2○(D×1.74533E¯2)))
[56]  X←H×T
[57]  Y←((¯4.9×T*2))+T×S×((1○(D×1.74533E¯2)))
[58]  →B[8]
[59]  X←S×T
[60]  Y←¯4.9×T*2
[61]  →B[8]
[62]  Y←(S×T)+¯4.9×T*2
[63]  →B[9]
[64]  X̲←(⌊/X),⌈/X
[65]  Y̲←(⌊/Y),⌈/Y
[56]  (X̲,Y̲)⌹X,Y
[67]  →B[10]
[68]  ⌹0
[69]  'TIME    DISTANCE'
[70]  ⍉((2,⍴T)⍴T,Y)
[71]  ⌹8
[72]  ⌹0
[73]  '      WHEN YOU ARE READY TO OBSERVE AN-'
[74]  'OTHER FLIGHT OF THE BODY, RESTART THE'
[75]  'PROGRAM BY TYPING AND ENTERING THE'
[76]  'LETTER P.'
 ∇
[77]
```

Sample Student Interaction

```
  P
        MOTION IN THE EARTH'S
         GRAVITATIONAL FIELD


                AUTHOR
           JOHN M. BOBLICK
               MAY  1969
     THIS PROGRAM SIMULATES THE MOTION
OF A BODY IN THE EARTH'S GRAVITATIONAL
FIELD.
TO CONTINUE, PRESS THE SPACE BAR.
     IF YOU ENTER THE INITIAL SPEED AND
THE INITIAL DIRECTION OF THE BODY, EX-
PRESSED AS THE ANGLE ABOVE THE HORI-
ZONTAL, A REPRESENTATION OF THE BODY'S
MOTION WILL BE DISPLAYED FOR YOU.
TO CONTINUE, PRESS THE SPACE BAR.
ENTER THE INITIAL SPEED (IN M/SEC) OF
THE BODY.
⎕:
  10
ENTER THE INITIAL DIRECTION OF THE BODY,
EXPRESSED AS THE ANGLE (IN DEGREES)
ABOVE THE HORIZONTAL. THE LIMITS ARE
0 - 90 DEGREES.
⎕:
  45
ENTER THE NUMBER (2-10) OF OBSERVATIONS
WHICH YOU WISH TO MAKE.
⎕:
  10
ENTER THE TIME INTERVAL (IN SEC)
BETWEEN OBSERVATIONS.
⎕:
  2

¯0.01+ ∘  ∘
     |        ∘   ∘
     |               ∘
¯0.46+
     |                   ∘
     |                      ∘
¯0.91+
     |                         ∘
     |
¯1.37+                             ∘
     |
     |
¯1.82+                                ∘
       +-----+-----+-----+-----+-----+-
     0.14  0.40  0.65  0.91  1.16  1.41
    X←X×10⋆ 02          Y←Y×10⋆ 03
```

Comment

This program is in the final stage of development but has not been validated with physics students.

i. A ONE-DIMENSIONAL ELASTIC COLLISION

Assessment of Need

The need for this program was determined by its author John M. Boblick,' based upon his previous classroom experience.

Description of the Program

This simulation depicts for the student a straight-line elastic collision of two masses, moving at constant velocities over a frictionless surface. The student selects the values for the masses of the bodies and their initial velocities. The IBM 1510 Instructional Display Unit presents a pictorial representation of the collision and reports the final velocity for each body. The student is then asked to make a generalization about the momentum of the system both before and after the collision.

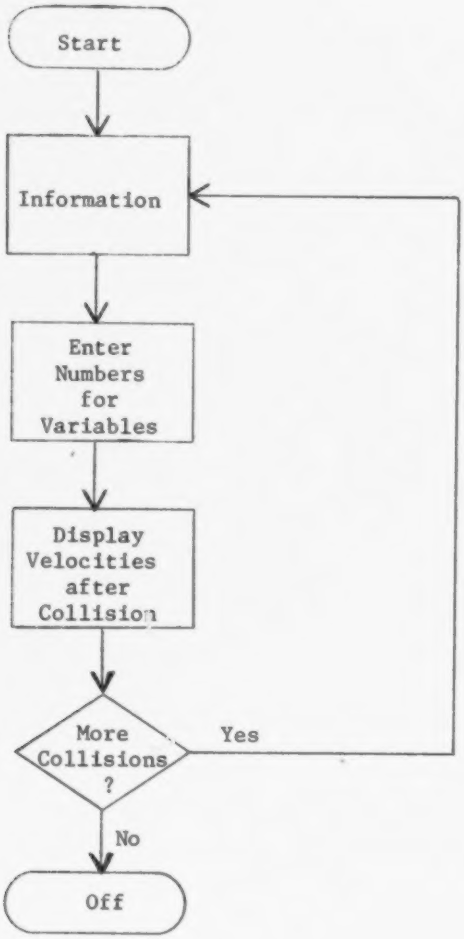
Designed and authored by John M. Boblick, this modular instructional package was coded into APL by its author in the spring of 1969.

Terminal Objective

Given data relative to a straight-line elastic collision of two masses moving at constant velocities over a frictionless surface, the student describes the relationship between the momentum of the system both before and after the collision.

A ONE-DIMENSIONAL ELASTIC COLLISION

INSTRUCTIONAL STRATEGY


Start
Information
Enter Numbers for Variables
Display Velocities after Collision
More Collisions ?
Yes
No
Off

Computer Program Printout

```
∇O[⎕]∇
∇O;X;Y;Z;W;X̲;B;C
[1]  V̲←64 68 28 23 40 35
[2]  ⌹0
[3]  ⌹4,4
[4]  '  A ONE-DIMENSIONAL ELASTIC COLLISION'
[5]  ''
[6]  ''
[7]  '                  AUTHOR'
[8]  '             JOHN M. BOBLICK'
[9]  '              FEBRUARY 1969'
[10]  ⌹7,300
[11]  ⌹0
[12]  '    THIS PROGRAM SIMULATES THE ELASTIC'
[13]  'STRAIGHT LINE COLLISION OF TWO BODIES.'
[14]  ''
[15]  '    GIVEN THE MASSES OF THE BODIES AND'
[16]  'THEIR VELOCITIES BEFORE THE COLLISION,'
[17]  'THE VELOCITIES AFTER THE COLLISION WILL'
[18]  'BE DETERMINED.'
[19]  ⌹4,12
[20]  'TO CONTINUE, PRESS THE SPACE BAR.'
[21]  ⌹8
[22]  ⌹0
[23]  'ENTER THE MASS(IN KG) OF BODY ONE.'
[24]  M←⎕
[25]  →V̲[3]×⍳M>0
[26]  'ENTER A POSITIVE VALUE FOR MASS.'
[27]  →V̲[4]
[28]  'MOTION TO THE RIGHT IS POSITIVE; MOTION'
[29]  'TO THE LEFT IS NEGATIVE.'
[30]  ''
[31]  'ENTER THE VELOCITY(IN M/SEC) OF BODY ONE'
[32]  'BEFORE THE COLLISION.'
[33]  U←⎕
[34]  ⌹0
[35]  'ENTER THE MASS(IN KG) OF BODY TWO.'
[36]  M̲←⎕
[37]  →V̲[5]×⍳M̲>0
[38]  'ENTER A POSITIVE VALUE FOR MASS.'
[39]  →V̲[6]
[40]  ''
[41]  'ENTER THE VELOCITY(IN M/SEC) OF BODY TWO'
[42]  'BEFORE THE COLLISION.'
[43]  U̲←⎕
[44]  →V̲[1]×⍳U≤U̲
[45]  →V̲[1]×⍳(U<0)∧(U̲>0)
[46]  →V̲[1]×⍳(U<0)∧(U̲<0)∧(|U≥|U̲)
[47]  →V̲[1]×⍳(U<0)∧(U̲=0)
[48]  →V̲[1]×⍳(U=0)∧(U̲≥0)
[49]  X←M-M̲
[50]  Y←M+M̲
```

```
[51]   Z←2×M
[52]   W←2×M̲
[53]   X̲←M̲-M
[54]   B←(.001×?5)-.001×?5
[55]   U←B+U
[56]   C←(.001×?5)-.001×?5
[57]   U̲←C+U̲
[58]   ⌹0
[59]   'THE VELOCITY(IN M/SEC) OF BODY ONE AFTER'
[60]   'THE COLLISION IS ';((X÷Y)×U)+((W÷Y)×U̲)
[61]   'THE VELOCITY(IN M/SEC) OF BODY TWO AFTER'
[62]   'THE COLLISION IS ';((Z÷Y)×U)+((X̲÷Y)×U̲)
[63]   →V̲[2]
[64]   'THE VELOCITY(IN M/SEC) OF BODY ONE'
[65]   'IS NOW ';U
[66]   'THE VELOCITY(IN M/SEC) OF BODY TWO'
[67]   'IS NOW ';U̲
[68]   ''
 ∇
[69]
```

Sample Student Interaction

```
  0
  A ONE-DIMENSIONAL ELASTIC COLLISION


                   AUTHOR
              JOHN M. BOBLICK
               FEBRUARY 1969
    THIS PROGRAM SIMULATES THE ELASTIC
STRAIGHT LINE COLLISION OF TWO BODIES.

    GIVEN THE MASSES OF THE BODIES AND
THEIR VELOCITIES BEFORE THE COLLISION,
THE VELOCITIES AFTER THE COLLISION WILL
BE DETERMINED.
TO CONTINUE, PRESS THE SPACE BAR.
ENTER THE MASS(IN KG) OF BODY ONE.
⎕:
   10
MOTION TO THE RIGHT IS POSITIVE; MOTION
TO THE LEFT IS NEGATIVE.

ENTER THE VELOCITY(IN M/SEC) OF BODY ONE
BEFORE THE COLLISION.
⎕:
   5
ENTER THE MASS(IN KG) OF BODY TWO.
⎕:
   15

ENTER THE VELOCITY(IN M/SEC) OF BODY TWO
BEFORE THE COLLISION.
⎕:
   -5
THE VELOCITY(IN M/SEC) OF BODY ONE AFTER
THE COLLISION IS ¯7.002
THE VELOCITY(IN M/SEC) OF BODY TWO AFTER
THE COLLISION IS  2.998
```

Comment

Initial use of this program began in the fall of 1970, and validation data was collected the following semester. For further details, see the Validation Data Section E. of this report.

j. THE AREA UNDER A CURVE

Assessment of Need

The need for this program was determined by the author, based upon his previous classroom experience.

Description of the Program

This modular instructional package makes use of the computer's capacity in primarily two ways. At the 1510 Instructional Display with light pen, the student may receive a drill and practice consisting of four problems and/or use a mathematical area estimating device. All instruction related to determining the area under a curve is provided through a mini-programmed textbook, which describes the process as well as student interaction with the computer terminal.

The computer programs and text were designed, authored, and programmed into APL by John M. Boblick in the fall of 1969.

Terminal Objective

Given a graphical representation of a curve (key points labeled) or an equation representing a curve, the student calculates the area under the curve for the limits selected.

Computer Program Printout

```
  ∇A[⎕]∇
∇A ⍙;X;Y;N;I
[1]  ⌹0
[2]  ⌹4,4
[3]  'AREA UNDER A CURVE --PROGRAM A'
[4]  ⌹4,7
[5]  'AUTHOR  JOHN M. BOBLICK'
[6]  'OCTOBER 1969'
[7]  ⌹7,300
[8]  ⌹0
[9]  X←1 2 3 4 5 6
[10]  Y←5+4×X
[11]  →14×⍳(⍙=0)
[12]  Y V̲ X
[13]  ⌹0
[14]  'INTO HOW MANY INTERVALS DO YOU'
[15]  'WISH TO DIVIDE THIS AREA ?'
[16]  N←⎕
[17]  →22×⍳(N≥2)∧(N≤250)
[18]  'PLEASE STAY WITHIN THE STATED LIMITS'
[19]  'OF 2 - 250 INTERVALS.'
[20]  ⌹7,300
[21]  →13
[22]  I←4÷N
[23]  X←1,1+I×⍳N
[24]  X←N↑X
[25]  Y←5+4×X
[26]  'THE AREA UNDER THE CURVE IS ';+/(I×Y)
 ∇
```

```
  ∇B[⎕]∇
∇B B̲;T;X;Y;E;N;I;W
[1]   ⌹0
[2]   ⌹4,4
[3]   'AREA UNDER A CURVE -- PROGRAM B'
[4]   ⌹4,7
[5]   'AUTHOR  JOHN M. BOBLICK'
[6]   'OCTOBER 1969'
[7]   ⌹7,300
[8]   ⌹0
[9]   'ENTER THE NUMBER (1 2 3 4) OF THE CURVE.'
[10]  T←⎕
[11]  X←0 1 2 3 4 5 6 7
[12]  →((T=1),(T=2),(T=3),(T=4))/13 14 15 16
[13]  →17,Y←2+X*.5
[14]  →17,Y←¯1+X*2
[15]  →17,Y←12+(¯6×X)+X*2
[16]  →17,Y←14+(5×X)+(¯1×X*2)
[17]  →20×⍳(B̲=0)
[18]  Y V̲ X
[19]  ⌹0
[20]  'ENTER MINIMUM AND MAXIMUM VALUES OF X.'
[21]  E←⎕
[22]  ⌹0
[23]  'INTO HOW MANY INTERVALS DO YOU'
[24]  'WISH TO DIVIDE THIS AREA ?'
[25]  N←⎕
[26]  →31×⍳(N≥2)∧(N≤250)
[27]  'PLEASE STAY WITHIN THE STATED LIMITS.'
[28]  'OF 2 - 250 INTERVALS.'
[29]  ⌹7,300
[30]  →22
[31]  I←(⌈/E-⌊/E)÷N
[32]  X←(⌊/E),(⌊/E)+I×⍳N
[33]  X←N↑X
[34]  →((T=1),(T=2),(T=3),(T=4))/35 36 37 38
[35]  →39,Y←2+X*.5
[36]  →39,Y←¯1+X*2
[37]  →39,Y←12+(¯6×X)+X*2
[38]  →39,Y←14+(5×X)+(¯1×X*2)
[39]  ⌹0
[40]  'THE AREA UNDER THE CURVE IS ';+/(I×Y)
[41]  ''
[42]  'ENTER THE NUMERAL 1 IF YOU WISH TO'
[43]  'COLLECT MORE DATA FOR CURVE NUMBER ';T
[44]  'IF YOU WISH TO STOP COLLECTING DATA FOR'
[45]  'CURVE NUMBER ';T;' ENTER A ZERO.'
[46]  W←⎕
[47]  →22×⍳(W=1)
[48]  ⌹0
[49]  'CALCULATE THE AREA UNDER THE CURVE'
[50]  'BEFORE YOU START ANOTHER PROBLEM.'
  ∇
  ∇C[⎕]∇
∇C C̲;X;Y;E;N;I;W;Z
[1]   ⍠0
[2]   ⍠4,4
[3]   'AREA UNDER A CURVE -- PROGRAM C'
[4]   ⍠4,7
[5]   'AUTHOR  JOHN M. BOBLICK'
[6]   'OCTOBER 1969'
[7]   ⍠7,300
[8]   ⍠0
[9]   'ENTER A SET OF VALUES FOR X.'
[10]   X←⎕
[11]   'ENTER AN EQUATION FOR THE CURVE.'
[12]   Z←⎕
[13]   →16×ι(C̲=0)
[14]   Z V̲ X
[15]   ⍠0
[16]   'ENTER MINIMUM AND MAXIMUM VALUES OF X.'
[17]   E←⎕
[18]   ⍠0
[19]   'INTO HOW MANY INTERVALS DO YOU'
[20]   'WISH TO DIVIDE THIS AREA ?'
[21]   N←⎕
[22]   →27×ι(N≥2)∧(N≤250)
[23]   'PLEASE STAY WITHIN THE STATED LIMITS'
[24]   'OF 2 - 250 INTERVALS.'
[25]   ⍠7,300
[26]   →18
[27]   I←(⌈/E-⌊/E)÷N
[28]   X←(⌊/E),(⌊/E)+I×ιN
[29]   X←N↑X
[30]   'ENTER YOUR EQUATION AGAIN.'
[31]   Z←⎕
[32]   ⍠0
[33]   'THE AREA UNDER THE CURVE IS ';+/(I×Z)
[34]   ''
[35]   'ENTER THE NUMERAL 1 IF YOU WISH TO'
[36]   'COLLECT MORE DATA FOR THIS CURVE.'
[37]   'ENTER A ZERO IF YOU DO NOT.'
[38]   W←⎕
[39]   →18×ι(W=1)
[40]   'ENTER C 1 OR C 0 TO TRY ANOTHER EQUATION'
 ∇
```

```
  ∇V̲[⎕]∇
∇Y V̲ X;X̲;Y̲
[1]  X̲←(⌊/X),⌈/X
[2]  Y̲←(⌊/Y),⌈/Y
[3]  →6×⍳((⍴X̲)≠⍴Y̲)
[4]  (X̲,Y̲)⌹X,Y
[5]  →0
[6]  'UNEQUAL LENGTH VECTORS ILLEGAL'
 ∇
```

Sample Student Interaction

```
  B 1
AREA UNDER A CURVE -- PROGRAM B
AUTHOR  JOHN M. BOBLICK
OCTOBER 1969
ENTER THE NUMBER (1 2 3 4) OF THE CURVE.
⎕:
  4

 2.00+          ∘   ∘
     |     ∘            ∘
     |
 1.50+ ∘                    ∘
     |
     |
 1.00+
     |                           ∘
     |
 0.50+
     |
     |
 0.00+                               ∘
       +-----+-----+-----+-----+-----+-
     0.00  1.40  2.80  4.20  5.60  7.00
    X←X×10* 00          Y←Y×10* 01
ENTER MINIMUM AND MAXIMUM VALUES OF X.
⎕:
  0 6
INTO HOW MANY INTERVALS DO YOU
WISH TO DIVIDE THIS AREA ?
⎕:
  200
THE AREA UNDER THE CURVE IS  102.089

ENTER THE NUMERAL 1 IF YOU WISH TO
COLLECT MORE DATA FOR CURVE NUMBER 4
IF YOU WISH TO STOP COLLECTING DATA FOR
CURVE NUMBER 4 ENTER A ZERO.
⎕:
  0
CALCULATE THE AREA UNDER THE CURVE
BEFORE YOU START ANOTHER PROBLEM.
```

Comment

Although the program remains in the developmental stage and has not been used by students, The Area Under A Curve has been employed for demonstrating the graphic capabilities of the CRT.

k. THE ANALYSIS OF LABORATORY DATA

Assessment of Need

The need for a program to aid in the analysis of laboratory data was determined by the author, based upon his classroom experiences.

Description of the Program

The purpose of this modular instructional package is to utilize the computer's capacity to assist the analysis of laboratory data. Using the IBM 1510 Instructional Display Unit, the student enters a series of numbers to represent dependent and independent variables. The program's plotting function depicts a graphical representation of the data entered. In a similar manner, the mean, standard deviation, and range for a given set of data will be calculated upon the student's request.

This modified simulation was designed, authored, and programmed into APL by John M. Boblick in the fall of 1970.

Terminal Objective

Given a set of laboratory data, the student analyzes it with respect to each enabling objective.

Entering Behaviors

The student:

1. Defines *mean, range, standard deviation, abscissa, ordinate, independent variable, dependent variable,* and *proportionality.*
2. Plots a graph when given values for dependent and independent variables.
3. Solves problems involving basic mathematical operations by using APL in the execution mode.

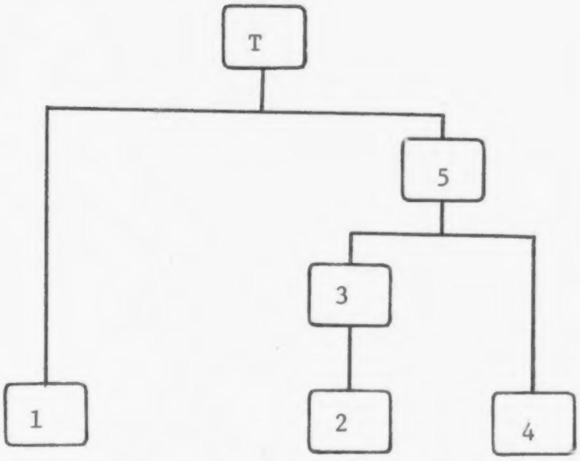
Enabling Objectives

The student:

1. Calculates the range, mean, and standard deviation for a set of laboratory data.
2. Plots a graph which depicts the relationship between the variables.
3. Identifies the relationship that exists between variables when given a graph.
4. Calculates the proportionality constant for a given relationship.
5. Expresses in equation form a relationship existing between variables.

THE ANALYSIS OF LABORATORY DATA

HIERARCHY



Computer Program Printout

```
  ∇S[⎕]∇
∇S;A;M;S̲
[1]  ⌹0
[2]  'ENTER DATA'
[3]  A←⎕
[4]  M←(+/A)÷ρA
[5]  S̲←((+/((A-M)*2))÷ρA)*.5
[6]  ''
[7]  'N  = ';ρA
[8]  'MEAN  = ';M
[9]  'STANDARD DEVIATION  = ';S̲
[10]  'RANGE  = ';⌊/A;' TO ';⌈/A
 ∇
```

```
  ∇V̲[⎕]∇
∇Y V̲ X;X̲;Y̲
[1]  X̲←(⌊/X),⌈/X
[2]  Y̲←(⌊/Y),⌈/Y
[3]  →6×ι((ρX̲)≠ρY̲)
[4]  (X̲,Y̲)⌹X,Y
[5]  →0
[6]  'UNEQUAL LENGTH VECTORS ILLEGAL'
 ∇
```

Sample Student Interaction

```
  S
ENTER DATA
⎕:
  10.0 11.4 12.5 13.7 16.8 29.3 33.5

N  = 7
MEAN  =  18.1714
STANDARD DEVIATION  =  8.66416
RANGE  = 10 TO  33.5
```

```
  X←1 2 3 4 5 6 7 8
  Y←1 4 9 16 25 36 49 64
  Y V X

 6.40+                               o
     |
     |
 4.83+                           o
     |
     |                      o
 3.25+
     |                  o
     |
 1.68+              o
     |          o
     |     o
 0.10+ o
       +-----+-----+-----+-----+-----+-
     1.00  2.40  3.80  5.20  6.60  8.00
    X←X×10⋆ 00          Y←Y×10⋆ 01
 X←.0204 .0278 .04 .0625 .1111 .25 1
 Y←7 6 5 4 3 2 1
 Y V X

7.00+ o
    |
    | o
5.50+
    |  o
    |
4.00+  o
    |
    |    o
2.50+
    |        o
    |
1.00+                               o
      +-----+-----+-----+-----+-----+-
    0.02  0.22  0.41  0.61  0.80  1.00
   X←X×10* 00          Y←Y×10* 00
```

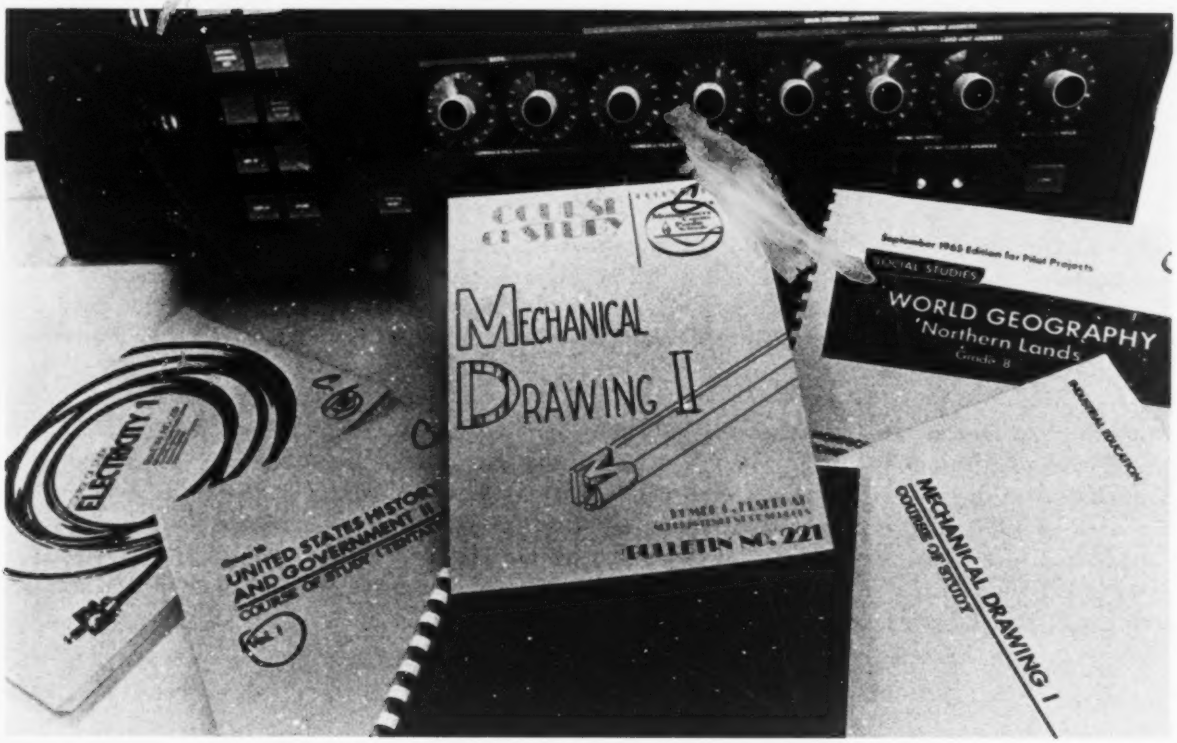
```
 X←1 2 3 4 5
 Y←5 7 9 11 13
 Y V X

1.30+                               o
    |
    |
1.10+                        o
    |
    |
0.90+                o
    |
    |
0.70+         o
    |
    |
0.50+ o
      +-----+-----+-----+-----+-----+-
    1.00  1.80  2.60  3.40  4.20  5.00
   X←X×10* 00          Y←Y×10* 01
```

Comment

This modular instructional package is still in the developmental stage.

5. OTHER SUBJECTS


COURSE OF STUDY
MECHANICAL DRAWING II
BULLETIN NO. 221
September 1965 Edition for Pilot Projects
SOCIAL STUDIES
WORLD GEOGRAPHY
'Northern Lands
Grade 8
INDUSTRIAL EDUCATION
MECHANICAL DRAWING I
COURSE OF STUDY
ELECTRICITY 1
UNITED STATES HISTORY
AND GOVERNMENT II
COURSE OF STUDY (TENTATIVE)

a. Fully Automatic Real-Time Computer Election (FARCE)

b. *Passé Composé* of Certain Verbs Conjugated with *Être*

c. Latitude and Longitude

d. Limit Dimensioning

e. Limit Dimensioning of Mating Machine Parts

THE DESIGN TEAM

Until the spring of 1969, only elementary school and secondary mathematics and science teachers had been identified for training in the supporting teachers' workshops. However, at the beginning of the third workshop, several French and social studies teachers were identified for training in the writing of modular instructional packages. These teachers would develop the first CAI curriculum "other" than mathematics and science for the IBM 1500 Instructional System. Three of these teachers developed the modules described in this section: James Dennis Cochran, social studies teacher at Newport Junior High School with six years teaching experience; Jeffrey A Schultz, social studies teacher at Parkland Junior High School with four years experience; and Anne Dudley, French teacher at White Oak Junior High School with six years teaching experience. In addition to their experience as classroom teachers, these individuals represented educational backgrounds that enabled them in writing materials for their respective subject areas.

James Dennis Cochran earned his B.A. at the University of Maryland and his M.A. at the George Washington University; Jeffrey A. Schultz received his B.A. degree from the State University of New York at New Paltz, and his M.S. from Pennsylvania State University; and Anne Dudley earned her B.A. in French from Queens College, Charlotte, North Carolina, and her M.A. in linguistics from American University.

When the CAI Project came to Einstein High School, an industrial arts teacher Don J. Konschnik, with an educational technology background, contacted the director about developing programs. Mr. Konschnik, working on his own time, designed and developed two modular instructional packages in the area of limit dimensioning. In addition to eleven years teaching experience, Don Konschnik participated in a 1969 summer workshop offered by the project. He earned his B.S. at Millersville State College and the M.Ed. at the University of Maryland and is currently enrolled in an educational technology graduate program at the Catholic University of America.

a. FULLY AUTOMATIC REAL-TIME COMPUTER ELECTION (FARCE)

Assessment of Need

This program was developed to give students an opportunity to identify the various inputs a candidate has to consider when running for a political office. It also demonstrates the computer's capabilities of employing the simulation technique in the social studies area.

Description of the Program

FARCE was written by James Dennis Cochran and Jeffrey A. Schultz in the fall of 1969, and coded in A PROGRAMMING LANGUAGE by Fred Dibbert and Anne Metzger. It utilizes the 1510 Instructional Display. Two high school students, Miriam Best and Kim Bernhardt, wrote the twelve political speeches which accompany the package.

Mode of Presentation

As the student enters this unique exercise in pragmatic politics, he is presented with a choice of four speeches he can make to his voters. They are: "Gun Control," "Public Housing," "Rapid Transit," and "The Vietnam War." Once he chooses the issue, he proceeds to assume a political position on the topic he has selected: conservative, moderate, or liberal. The computer analyzes his choice of topics and political approach and provides him with a printout indicating how his speech appealed to the voters. This printout, which he is given to take home and analyze at his own leisure, further provides a breakdown into age levels, income, location, and educational levels of his constituents.

```
  F
WHAT IS THE TOPIC OF THIS SPEECH?(ENTER A,B,C, OR D)
B
WHICH SPEECH DID YOU GIVE ON ISSUE A (ENTER 1,2,OR 3)
⎕:
  2
ENTER YOUR CHOICE OF SPEECHES ON ISSUE B
⎕:
  3
A POLL HAS BEEN TAKEN TO MEASURE THE IMPACT OF YOUR SPEECH
RESULTS OF THE POLL ON ISSUE B
       GROUPS AND PROPORTION FOR YOU
LOCATION:  URBAN= 0.4  SUBURBAN= 0.4  RURAL= 0.6
INCOME:  >20,000= 0.4  10,000-20,000= 0.4  <10,000= 0.6
EDUCATION:  >14YRS= 0.4  HS-14YRS= 0.4  8-12YRS= 0.45  <8YRS= 0.6
AGE:  65+YRS= 0.6  45-65YRS= 0.45  30-45YRS= 0.4  21-30YRS= 0.4

       *******

CUMULATIVE IMPACT OF ALL FOUR ISSUES
       GROUPS AND PROPORTION FOR YOU
LOCATION:  URBAN= 0.5  SUBURBAN= 0.466667  RURAL= 0.5
INCOME:  >20,000= 0.466667  10,000-20,000= 0.5  <10,000= 0.5
EDUCATION:  >14YRS= 0.466667  HS-14YRS= 0.466667  8-12YRS= 0.475  <8YRS= 0.5
AGE:  65+YRS= 0.5  45-65YRS= 0.475  30-45YRS= 0.5  21-30YRS= 0.466667

     ********************
IF THE ELECTION WERE HELD TODAY
96875  PEOPLE WOULD VOTE FOR YOU
THIS IS   0.484375  PROPORTION OF THE TOTAL
 0.515625  PROPORTION WOULD VOTE FOR YOUR OPPONENT
```

Computer Program Print-Out

```
  ∇F[⎕]∇
∇F;A;D;E;G;I;I;L;N;N;P;P;S;T;W;R;C
[1]  L←14 21 26 27 33 35 42 44 47 54 62 64 70 72 74 76
[2]  N←200000
[3]  P←.50 .30 .20 .20 .70 .10 .20 .40 .30 .10 .10 .20 .30 .40
[4]  P←14 5ρ0
[5]  P[;5]←N×P
[6]  P[;1]←2 3 3 1 2 3 3 1 3 3 3 3 2 1
[7]  P[;2]←1 1 3 1 1 3 1 1 2 3 3 2 1 1
[8]  P[;3]←2 2 1 2 2 1 3 2 1 1 1 2 2 3
[9]  P[;4]←2 3 3 1 2 3 1 2 3 3 3 3 2 1
[10]  S←14 5 ρ .50
[11]  W←2 4 ρ (N÷2)
[12]  W[2;]←2 1 1 2
[13]  E←'ABCD'
[14]  'WHAT IS THE TOPIC OF THIS SPEECH?(ENTER A,B,C, OR D)'
[15]  I←⍞
[16]  →((ρI)>1)/L[1]
[17]  →(~(I∊E))/L[1]
[18]  I←+/((E∊I)×(⍳4))
[19]  →(I=1)/L[4]
[20]  C←1
[21]  'WHICH SPEECH DID YOU GIVE ON ISSUE ';E[C];' (ENTER 1,2,OR 3)'
[22]  A←⎕
[23]  →((A>3)∨(A<1))/L[2]
[24]  G←L[3]
[25]  →L[11]
[26]  →((C←C+1)<I)/L[2]
[27]  'ENTER YOUR CHOICE OF SPEECHES ON ISSUE ';E[I]
[28]  A←⎕
[29]  →((A>3)∨(A<1))/L[4]
[30]  G←L[5]
[31]  C←I
[32]  →L[11]
[33]  'A POLL HAS BEEN TAKEN TO MEASURE THE IMPACT OF YOUR SPEECH'
[34]  'RESULTS OF THE POLL ON ISSUE ';E[I]
[35]  '       GROUPS AND PROPORTION FOR YOU'
```

```
    ∇F[⎕36]∇
[36]  'LOCATION:  URBAN=';S[1;C];'  SUBURBAN=';S[2;C];'  RURAL=';S[3;C]
[37]  'INCOME:  >20,000=';S[4;C];'  10,000-20,000=';S[5;C];'  <10,000=';S[6;C]
[38]  'EDUCATION:  >14YRS=';S[7;C];'  HS-14YRS=';S[8;C];'  8-12YRS=';S[9;C];'  <8YRS=';S[10;C]
[39]  'AGE:  65+YRS=';S[11;C];'  45-65YRS=';S[12;C];'  30-45YRS=';S[13;C];'  21-30YRS=';S[14;C]
[40]  →(I=9)/L[10]
[41]  C←0
[42]  →((C←C+1)>4)/L[9]
[43]  R←0
[44]  →((R←R+1)>14)/L[7]
[45]  S[R;5]←(+/(S[R;⍳4]×W[2;⍳4]))÷(+/(W[2;]))
[46]  →L[8]
[47]  I←9
[48]  C←5
[49]  ' '
[50]  '          *******'
[51]  ' '
[52]  'CUMULATIVE IMPACT OF ALL FOUR ISSUES'
[53]  →L[6]
[54]  ' '
[55]  '      ********************'
[56]  'IF THE ELECTION WERE HELD TODAY'
[57]  T←((+/(W[1;]×W[2;]))÷(+/(W[2;])))
[58]  ⌈T;'  PEOPLE WOULD VOTE FOR YOU'
[59]  'THIS IS  ';T÷N̲; '  PROPORTION OF THE TOTAL'
[60]  1.00-(T÷N̲);'  PROPORTION WOULD VOTE FOR YOUR OPPONENT'
[61]  →0
[62]  R←0
[63]  D←A-P[;C]
[64]  →((R←R+1)>14)/L[16]
[65]  →((|D[R])=1)/L[13]
[66]  →((|D[R])=2)/L[14]
[67]  →(((|D[R])=0)∧(A=2))/L[15]
[68]  S[R;C]←.60
[69]  →L[12]
[70]  S[R;C]←.45
[71]  →L[12]
```

```
  ∇F[⎕72]∇
[72]  S[R;C]←.40
[73]  →L[12]
[74]  S[R;C]←.55
[75]  →L[12]
[76]  W[1;C]←(+/(S[;C]×P[;5]))÷4
[77]  →G
 ∇
```

Comment

FARCE, which is still in the developmental stage, has not been used with students.

b. *PASSÉ COMPOSÉ* OF CERTAIN VERBS CONJUGATED WITH *ÊTRE*

Assessment of Need

Since the study of verbs occupies an integral part of the French program and a student must master these verb tenses before continuing further in the language, it was decided that a MIP of this type was appropriate and needful.

Description of the Program

This tutorial program, which utilizes the 1510 Instructional Display with keyboard and light pen, is designed primarily for students in French I and French II. It was written by Anne H. Dudley and programmed in COURSEWRITER II by Priscilla Smith and Barbara Bieri.

Terminal Objective

Given the subject of a sentence and the infinitive of a verb which requires a form of *être* in the past tense and which requires the correct agreement in gender and number, the student constructs the verb form.

Entering Behaviors

1. Given the conjugation of the present tense of *être* and a sentence requiring a form of *être*, the student identifies the missing verb.

2. Given a sentence in which the predicate adjective is missing, the student constructs the adjective which agrees with the subject in gender and number.

3. The student demonstrates orally the use of the past tense described in this program.

Enabling Objectives and Hierarchy

The objectives and their sequencing are not included in this description.

Pretest

Fill in each blank with the *passé composé* of the verb in parentheses.

1. Jacqueline _____________ (tomber).

2. Ils _____________ de bonne heure.
   (rentrer)

3. Vous _____________ au cinema, Madame.
   (aller)

4. Paul et moi, nous _____________ en.
   (aller)

5. Je ____________ de bonne heure.
(rentrer)

6. Tu ____________ en ville, Paul.
(rester)

Posttest

Fill in each blank with the *passé composé* of the verb in parentheses.

1. Jacqueline ____________ (tomber).

2. Ils ____________ de bonne heure.
(rentrer)

3. Vous ____________ au cinéma, Madame.
(aller)

4. Paul et moi, nous ____________ en ville.
(aller)

5. A boy says: Je ____________ de bonne heure.
(rentrer)

6. Vous ____________ à l'heure, mes amies.
(arriver)

7. Paul ____________ en retard.
(arriver)

8. Tu ____________ en ville, Marie.
(rester)

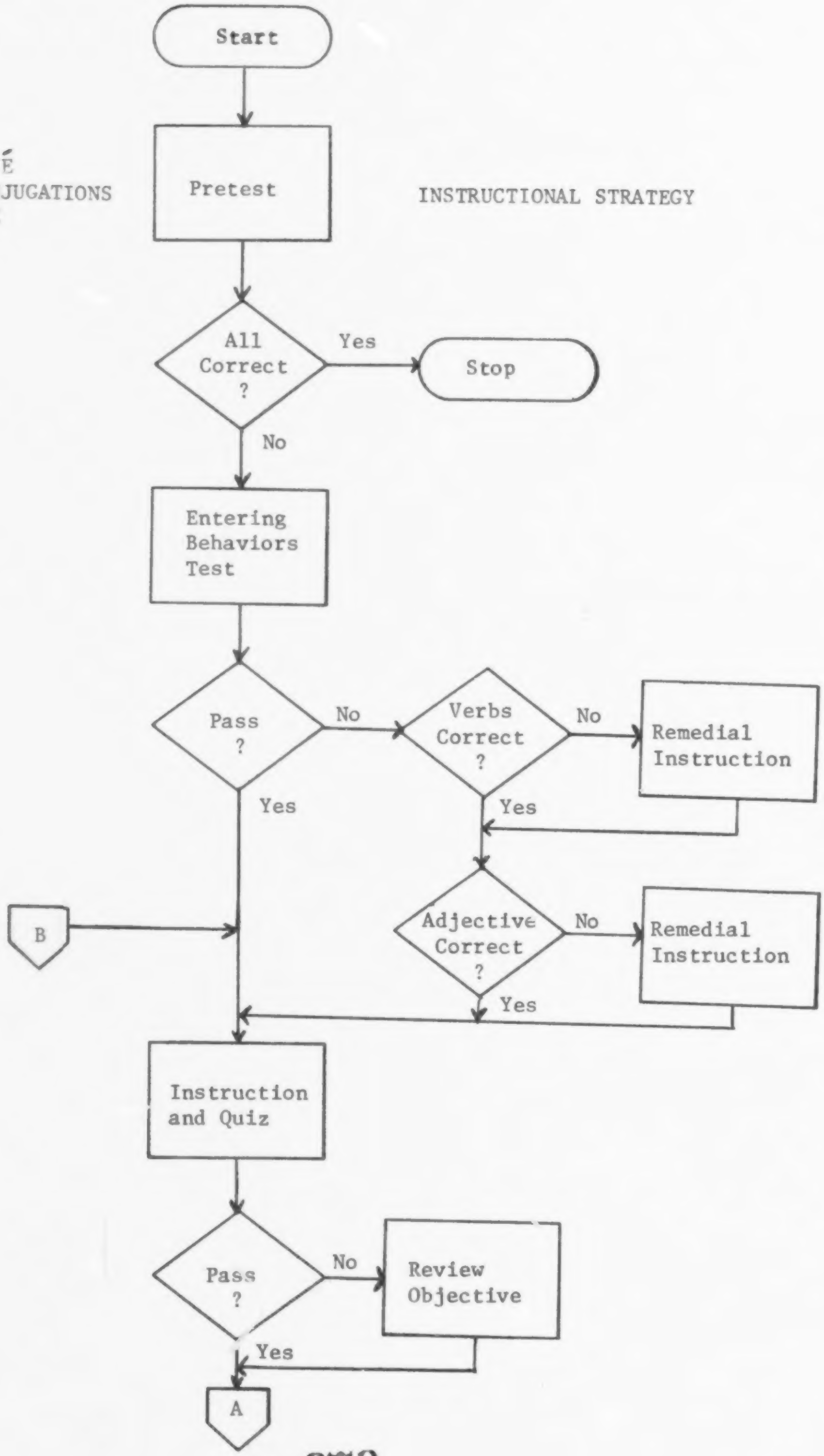
9. Elles ____________ dans le restaurant.
(entrer)

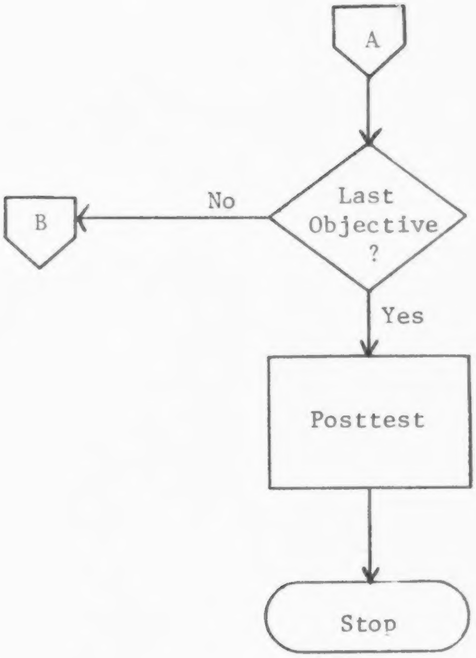
Mode of Presentation

As the student begins this program, the teacher provides him with an accent guide to use at the keyboard. While some students are on-line, the teacher can give individual assistance to the students in class and provide further oral practice. Since the study of French demands much oral practice, this is a desirable technique for it permits greater freedom and flexibility of the class and allows the teacher more time for emphasizing the spoken language.

PASSÉ COMPOSÉ
OF CERTAIN VERB CONJUGATIONS
WITH ÊTRE

INSTRUCTIONAL STRATEGY


Start
Pretest
All Correct ?
Yes
Stop
No
Entering Behaviors Test
Pass ?
No
Verbs Correct ?
No
Remedial Instruction
Yes
Yes
B
Adjective Correct ?
No
Remedial Instruction
Yes
Instruction and Quiz
Pass ?
No
Review Objective
Yes
A


A
Last Objective ?
No
B
Yes
Posttest
Stop

Sample Section of Program

A past tense in French

The Passé Composé

S

Some verbs are conjugated with "être" in the passé composé.

S

You will be working with verbs which use "être" as the helping verb to form the passé composé.

S

Point to the past participle of each verb given below:

rentrer

☐ rentré
☐ rester
☐ rentrez

P

Now look at another set of sentences:

Vous êtes allé en ville, monsieur?
Vous êtes allée en ville, madame?
Vous êtes allés en ville, mes amis?
Vous êtes allées en ville, mes amies?

S

Fill in each blank with the past participle of the verb given.

A girl says,

Paul et moi, nous sommes ☐____ en ville. (aller)

K

Comment

This program was completed in the summer of 1969 but has not been used with students.

c. LATITUDE AND LONGITUDE

Assessment of Need

This program was developed to instruct junior high students in latitude and longitude, the basic tools of geographic measurement. It was felt that many seventh and eighth grade students often experience severe difficulty in mastering these concepts.

Description of the Program

This tutorial program was designed and developed by James Dennis Cochran and Jeffrey A. Schultz. It utilizes the 1510 Instructional Display with keyboard and light pen. The package will be coded in COURSEWRITER II.

Mode of Presentation

Before entering this program, the student is tested off-line and then provided with complete instructions for progressing through the MIP.

Terminal Objectives

T1 Given a globe of the earth and five designated cities, the student, in six minutes, determines the proper latitude and longitude coordinates for each city with a two-degree margin of error.

T2 Given a globe of the earth and five sets of latitude and longitude coordinates, the student, in five minutes, determines which cities are indicated by the stated coordinates.

Entering Behaviors

E1 The student completes the entry program.

E2 Given a line segment and a list of measuring instruments, the student identifies the ruler as the most appropriate instrument for obtaining linear measurements.

E3 Given a set of four mathematical problems, the student adds, subtracts, multiplies, and divides whole numbers and fractions.

E4 Given the following list of terms and sets of illustrations, the student matches them: grid, line, globe, sphere, circle, rectangle, segment, midpoint, interval, endpoint.

Enabling Objectives

A Given the name of four geometric shapes, the student identifies the earth as a sphere.

B Given a satellite photograph of the earth and a globe, the student identifies that markings drawn on a globe as a representation of the earth are imaginary and used for establishing location.

C1 Given a representation of earth with latitude arcs, the student states that arcs of latitude, when removed from the globe, lie on circles of varying diameter.

D1 Given a replica of earth with markings (latitude arcs), the student identifies these as arcs.

E1 Given a replica of earth with latitude arcs, the student identifies the equator. (0°)

F1 Given a representation of earth with the equator, the student names the cardinal directions North and South.

G1 Given a replica of earth, the student constructs a wind rose with the cardinal directions North and South.

H1 Given a replica of earth with the equator, the student identifies that the equator divides the earth into two equal parts, each of which is called a hemisphere.

I1 Given a three-dimensional replica of earth with planes formed by latitude arcs, the student states that these planes are parallel to each other by selecting the correct multiple choice item.

J1 Given a representation of the northern hemisphere with latitude arcs, the student labels these arcs at 15° intervals starting from the equator to 90° N., e.g., 15° N, 30° N.

J1A Given a drawing of a line segment and an angle, the student distinguishes between linear and angular measurement by correctly identifying which type of measurement would be used for each drawing.

J1B Given a protractor and a set of 40° angles which have different length line segments, the student measures these angles within 2°.

J1C Given a set of three diagrams illustrating the construction of latitude lines, the student identifies the correct process.

K1 Given a representation of the southern hemisphere with latitude arcs, the student labels these arcs at 15° intervals starting from the equator to 90° S., e.g., 15° S, 30° S.

L1 Given a replica of earth with latitude arcs, the student states that latitude degrees in the northern hemisphere have complementary latitude degrees in the southern hemisphere.

M1 Given a globe with latitude lines only and Peking, Denver, Madrid, Philadelphia, and Ankara indicated, the student identifies the latitude locations at 30° N.

C2 Given a globe, the student constructs arcs of longitude and states that when these arcs are removed from the globe, they always lie on circles of equal diameter.

E2 Given a replica of earth with 0° indicated on an arc, the student identifies this as the Prime Meridian and the longitudinal point of reference.

F2 Given a replica of earth with the Prime Meridian indicated, the student names the eastern and western hemispheres.

G2 Given a representation of earth, the student names the cardinal directions East and West.

H2 Given a replica of earth, the student constructs a wind rose indicating the cardinal directions North, South, East, and West.

J2 Given a representation of the western hemisphere with arcs of longitude indicated, the student labels these arcs at 15° intervals starting from the Prime Meridian to 180° West.

J2A Given a globe with longitude arcs indicated and three diagrams, the student identifies the polar perspective.

J2B Given five locations, the student identifies these expressed in degrees, minutes, and seconds.

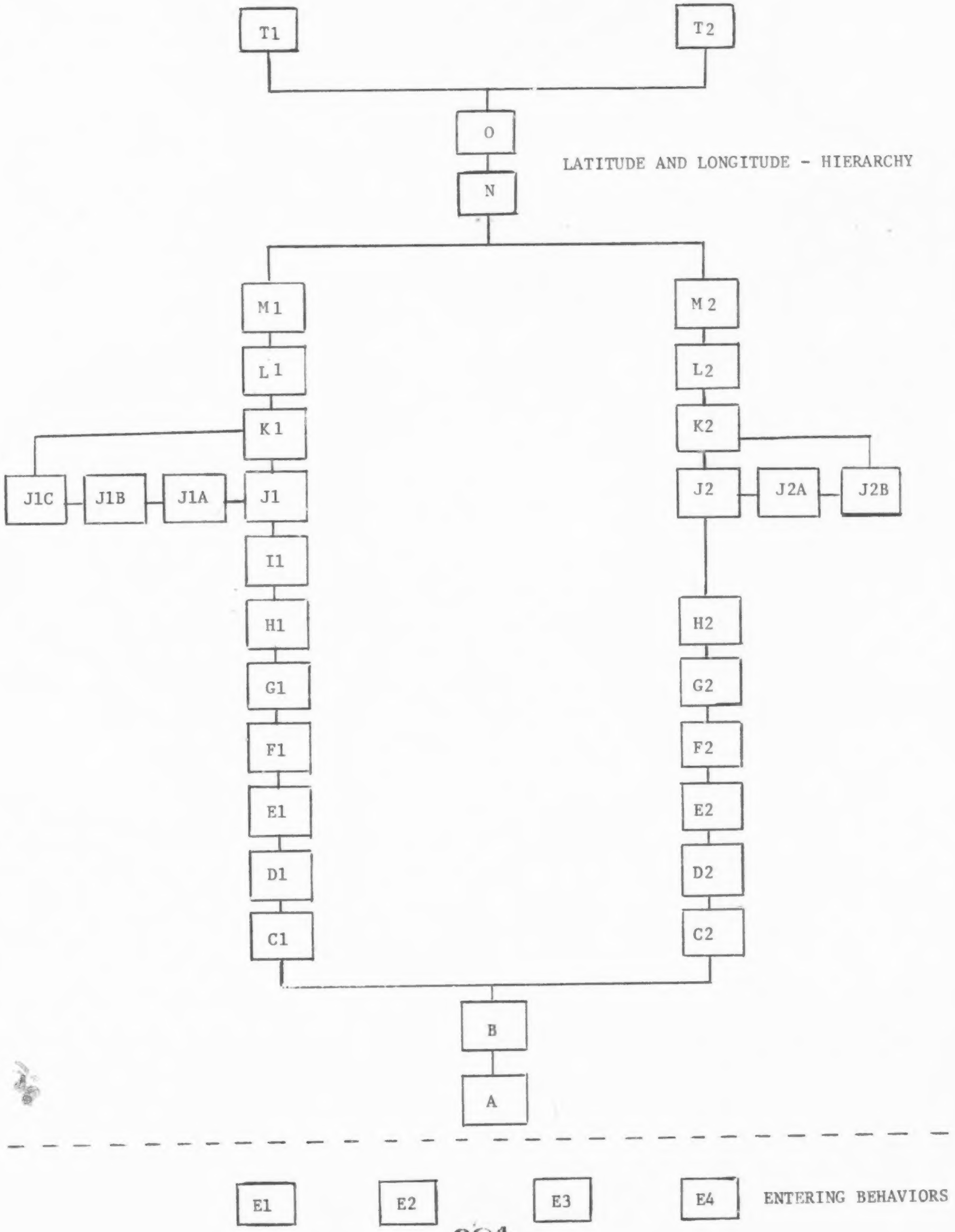
K2 Given a representation of the eastern hemisphere with arcs of longitude indicated, the student labels these arcs at 15° intervals starting from the Prime Meridian to 180° East.

L2 Given a replica of earth with arcs of longitude indicated, the student states that longitude degrees in the western hemisphere have complementary longitude degrees in the eastern hemisphere.

M2 Given a globe with longitude lines only and Pittsburgh, Toronto, Miami, Panama City, and Guayaquil indicated, the student identifies these at 80° West longitude.

N Given sets of latitude-longitude coordinates, the student states that locational grids are stated in terms of latitude and then in terms of longitude by identifying which three are in the correct order.

O Given a map of the U.S. containing six lettered locations and degrees of latitude and longitude and five sets of latitude and longitude coordinates, the student matches the appropriate location to its coordinates within five minutes.


LATITUDE AND LONGITUDE - HIERARCHY

T1
T2
O
N
M1
M2
L1
L2
K1
K2
J1C
J1B
J1A
J1
J2
J2A
J2B
I1
H1
H2
G1
G2
F1
F2
E1
E2
D1
D2
C1
C2
B
A
E1
E2
E3
E4
ENTERING BEHAVIORS

Pretest and Posttest

Both pretest and posttest, given off-line, are identical to the terminal objectives.

Sample Section of Program

Instructor: Gentlemen, fundamental to the space program is communication of where you are at a given point in time. Today you will be put through a computer program that will give you the basic skills necessary to transmit your exact location on earth.

S

Early man was confused but finally came up with the brainstorm of using the direction of winds.

S

The arc of latitude that divides the North and South Hemispheres is the Equator.

The Equator is the visual marking that represents a PLANE which cuts through the Earth.

S

Comment

The program is still in the developmental state.

d. LIMIT DIMENSIONING

Assessment of Need

It was felt that a need existed for demonstrating computer-assisted instruction in the area of industrial education, thereby exploring the posibility of utilizing this medium to teach information used in industry. The topic was chosen for its appropriateness to prejob and on-the-job training for industrial workers as well as for its applicability to secondary industrial arts and technical courses. Limit dimensioning is used over a broad range of industrial applications and is not confined to one branch or segment of industry.

Description of the Program

Limit dimensioning is related to mechanical drawing but has implications for most industrial education courses. It is a process by which close tolerances can be maintained on sizes of interchangeable machine parts. This tutorial program employs the 1510 Instructional Display Unit with keyboard and light pen. Designed and written by Don J. Konschnik, the package was completed in the spring of 1970 and coded in COURSEWRITER II by Michael Dyson and Sinval Martins.

Terminal Objective

Given the nominal size and the tolerance expressed verbally, the student applies limit dimensions to any measurement.

Entering Behaviors

The student:

1. Interprets dimensions on circular details to be diameters.
2. Applies basic rules of dimensioning machine drawings.
3. Names sample machine parts drawn orthographically.
4. Adds and subtracts decimal fractions to five places.
5. Derives decimal fractions from a decimal equivalent chart.

Enabling Objectives

The student:

1. Defines nominal size as a general description of a dimension which is given in terms of a common fraction.
2. Defines basic size as the decimal equivalent of the nominal size and from which the limits are derived.
3. Writes the basic size, given the nominal size.

4. Defines tolerance as the amount of error allowed on one dimension.

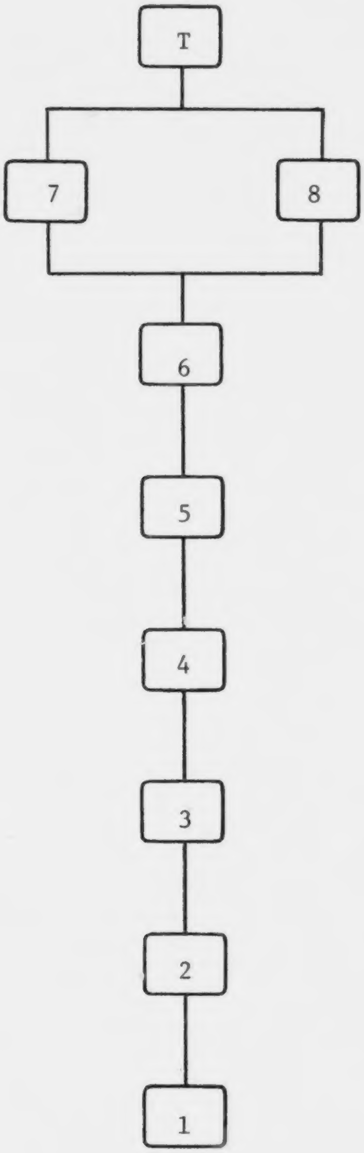
5. Defines limits as the largest and smallest size to be accepted on one dimension in the manufacture of a machine part.

6. Writes limits, given the basic size and tolerance.

7. Applies limits to inside dimensions of holes and slots with the smaller limit above the dimension line and the larger limit below.

8. Applies limits to outside dimensions of pins, keys, and shafts with the larger limit above the line and the smaller limit below.

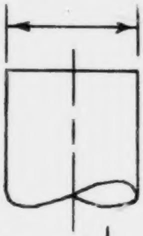
LIMIT DIMENSIONING - HIERARCHY



Limit Dimensioning

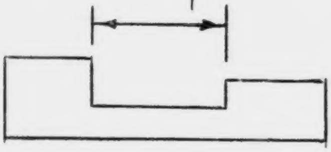
Pretest and Posttest (Off-line)

1. Dimension the three drawings below expressing the tolerance as limits.



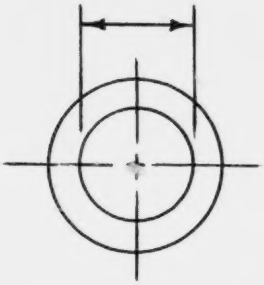
Nominal Size: 3/4

Tolerance: Plus or minus three thousandths



Nominal Size: 1/2

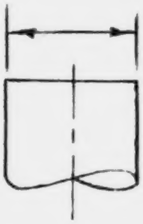
Tol: Plus or minus two thousandths



Nominal Size: 1 1/4

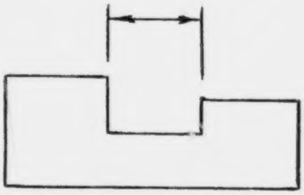
Tol: Five thousandths, more or less

2. Dimension the three drawings below expressing the tolerance as a plus or minus.



Nominal Size: 1 3/4

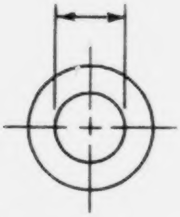
Tol: Plus or minus seven thousandths



Nominal Size: 1/8

Tol: Plus or minus one thousandth

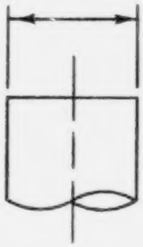
2.
con't



Nominal Size: 5/8

Tol: Five thousandths more or less

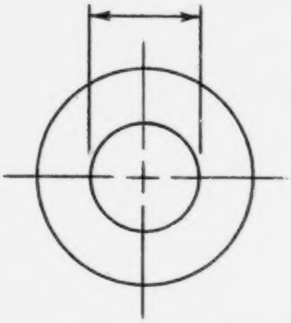
3.



Apply limits to the shaft on the left:

Nominal Size: 1 7/8

Tol: Plus or minus six thousandths



Apply limits to the hole shown on the left:

Nominal Size: 3/8

Tol: Plus or minus one thousandth

4. On a dimension, the nominal size is 3 1/4 inches and the tolerance is plus or minus five thousandths. What are the limits for this measurement?

5. Limits are the ______ and ______ permitted sizes to be accepted on one ______ in the manufacture of a machine part.

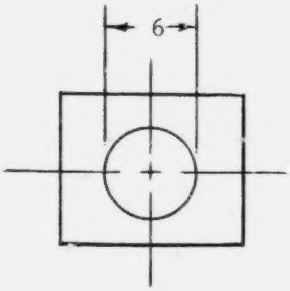
6. Tolerance is the amount of manufacturing ________ allowed on one ________.

7. What is the basic size of a 1/2" dimension?

8. The basic size of a measurement is the decimal equivalent of the ______ ______.

9. The general description of a dimension which is given in terms of a common fraction is ______ ______.

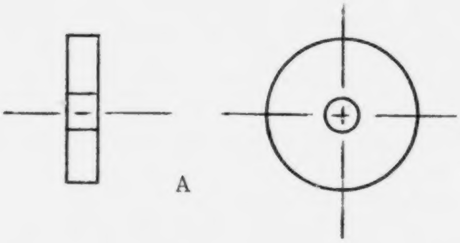
10.

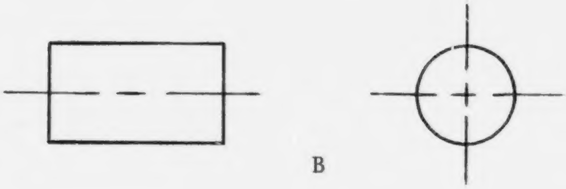


The 6 represents the __________ of the hole shown on the left.

11. Given the following information, correctly dimension the two drawings below:

Drawing A:	Drawing B:
Thickness - 1/4	Length - 2"
Outside Diameter - 1 1/2"	Diameter - 1"
Inside Diameter - 1/4"	


A


B

12. Solve the following arithmetic problems:

A. 1.006	B. 1.000	C. 5.00002	D. 8.250
+1.002	-.956	-.00151	+.005

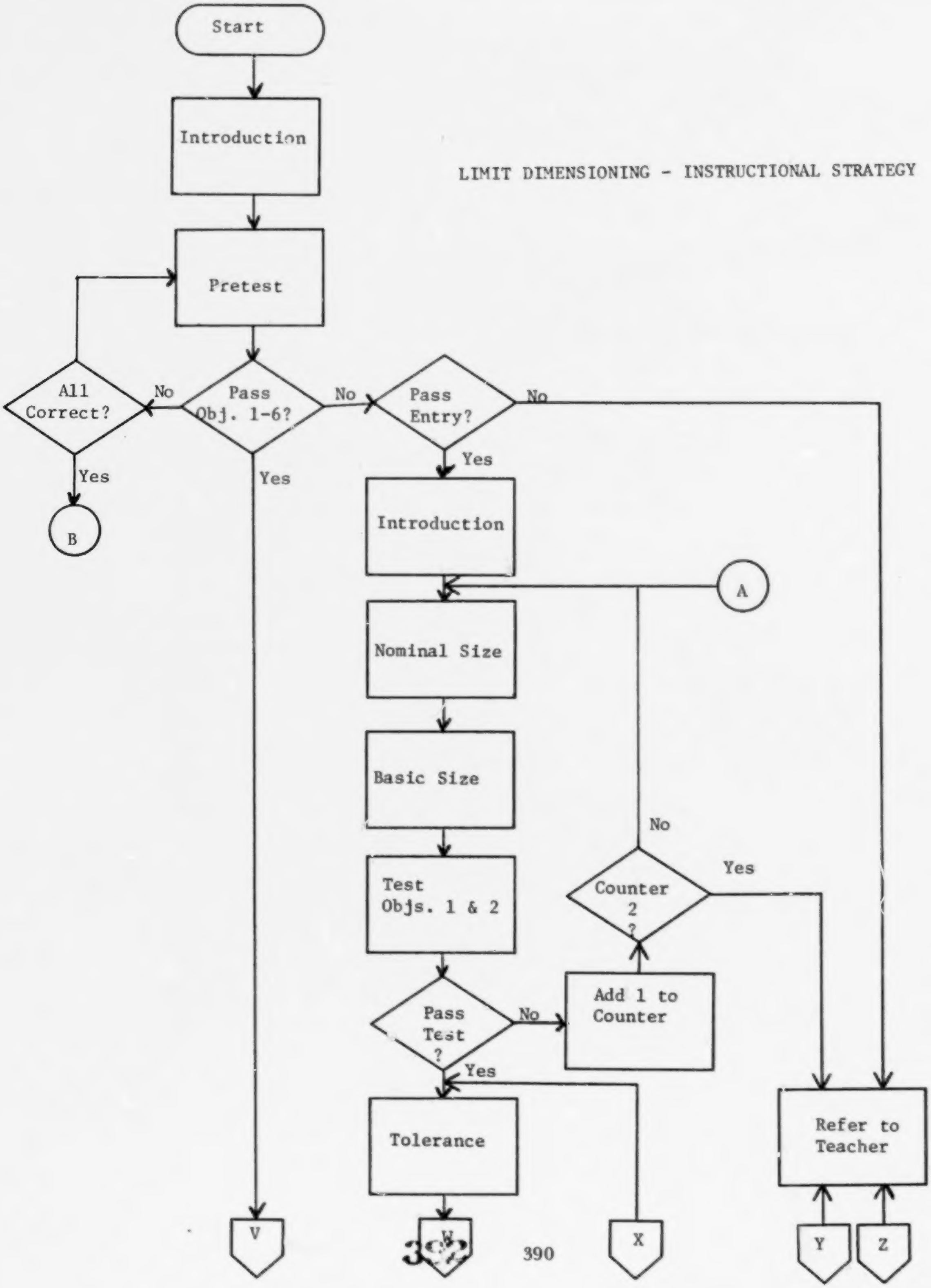
13. Supply the common or decimal fraction (whichever is missing) in the group below:

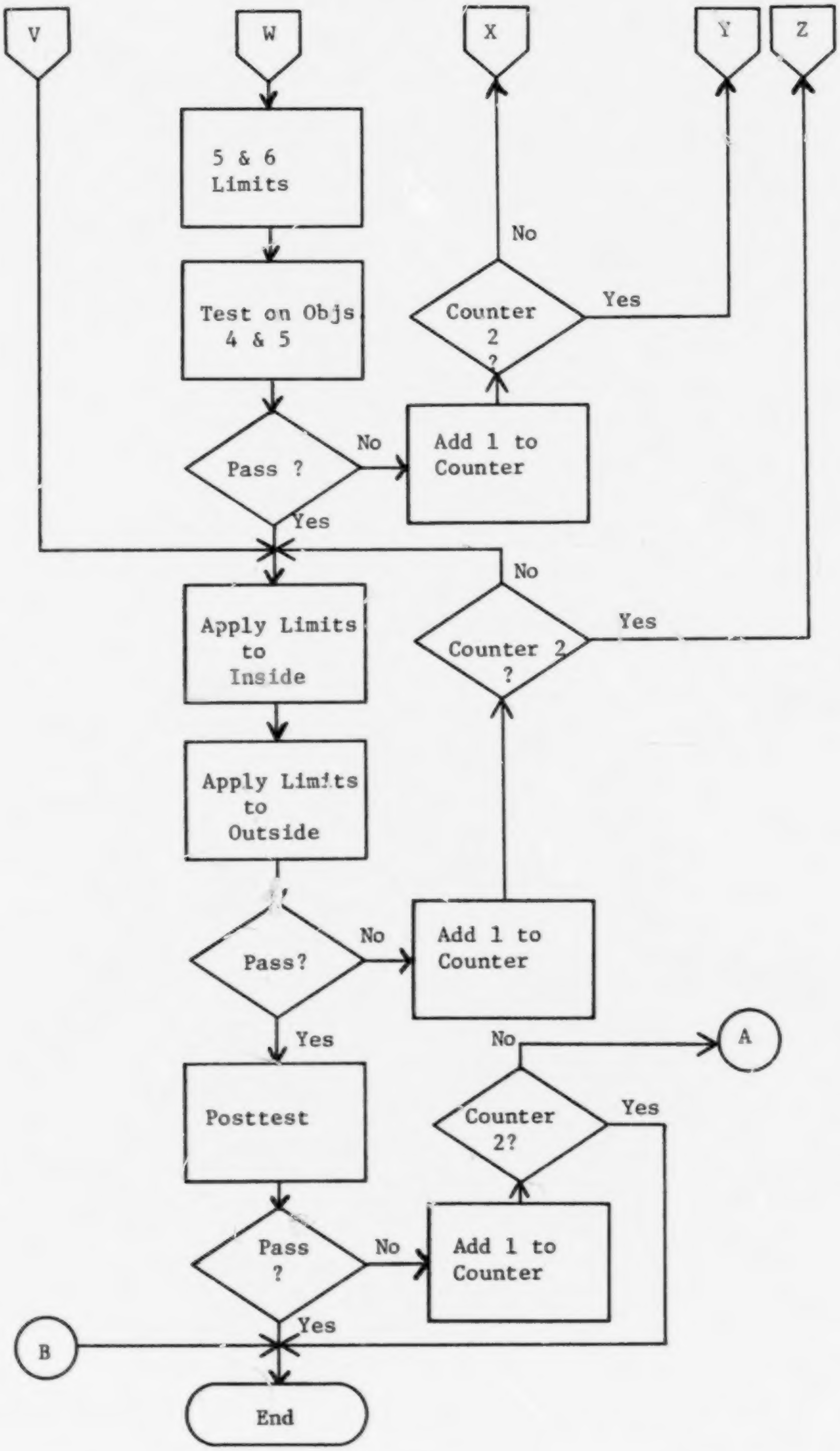
	COMMON DECIMAL		DECIMAL FRACTION
A.	1/2	=	_____
B.	3/8	=	_____
C.	_____	=	.750
D.	3/32	=	_____
E.	_____	=	.984375

Mode of Presentation

The student is given an on-line introduction to the program and is then pretested. Both pretest and posttest may be administered on-line as well as off-line. (See Pretest and Posttest section). As he progresses through the program, he is provided with a student flipbook consisting of a computation sheet, a decimal equivalent chart, and scale drawings.

LIMIT DIMENSIONING - INSTRUCTIONAL STRATEGY


Start
Introduction
Pretest
All Correct?
No
Pass Obj. 1-6?
No
Pass Entry?
No
Yes
B
Yes
Yes
Introduction
A
Nominal Size
Basic Size
No
Yes
Counter 2 ?
Test Objs. 1 & 2
Add 1 to Counter
Pass Test ?
No
Yes
Tolerance
Refer to Teacher
V
W
X
Y
Z


V
W
X
Y
Z
5 & 6 Limits
Test on Objs 4 & 5
Pass ?
No
Yes
Add 1 to Counter
Counter 2 ?
No
Yes
Apply Limits to Inside
Apply Limits to Outside
Counter 2 ?
No
Yes
Pass?
No
Yes
Add 1 to Counter
Posttest
Counter 2?
No
Yes
A
Pass ?
No
Yes
Add 1 to Counter
B
End

Sample Section of Program

Basic size is the exact statement of the nominal size. Basic size is the decimal equivalent of the nominal size.

S

Write the basic sizes for the nominal sizes shown below. (Use page 100.)

	Nom. Size	Basic size
a	1/2=	☐ ____
b	3/4=	☐ ____
c	1/4=	☐ ____

K

Indicate the nominal size(s) in the list below:

Now indicate the basic size(s).

A 3/8	D ±.002
B ±.006	E $\frac{1.008}{1.006}$
C .375	F .750

P

Comments

This program was pilot tested with students in the fall of 1970. Validation is planned for the 1971 school year.

e. LIMIT DIMENSIONING OF MATING MACHINE PARTS

This is the second modular instructional package written by Don J. Konschnik and is a sequel to the author's Limit Dimensioning program. **Assessment of Need, Description of the Program,** and **Mode of Presentation** are the same for both MIP's.

Terminal Objective

Given the nominal size, allowance, and maximum clearance, the student limit dimensions a transition fit between mating machine parts.

Entering Behavior

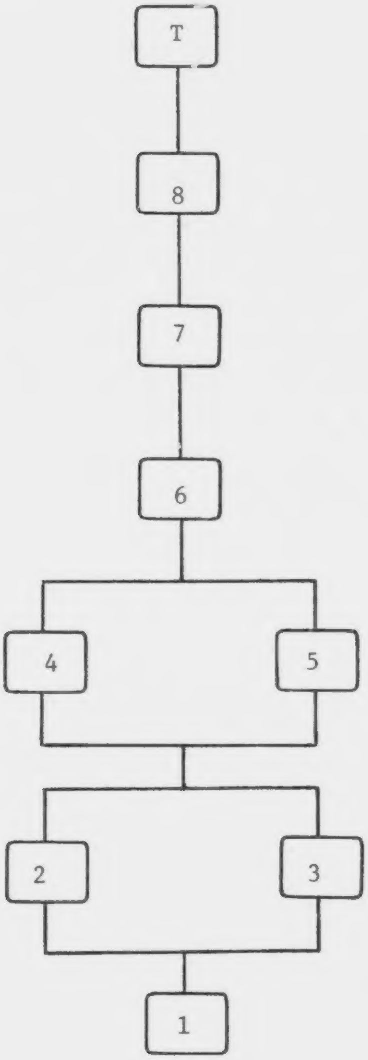
Given the nominal size and the tolerance expressed verbally, the student applies limit dimensions to any measurement, using a decimal equivalent chart, pencil, paper, and drawings of simple machine parts.

Enabling Objectives

The student:

1. Identifies and describes mating parts shown in a machine drawing, the description including mention of at least one common critical dimension.
2. Defines allowance as the minimum clearance (or maximum interference) intended between mating parts.
3. Defines maximum clearance as the loosest fit between mating parts which occurs when the smallest shaft is matched with the largest hole.
4. Defines the basic shaft system as applying the basic size to the space above the dimension line for the shaft or outside measurement.
5. Defines the basic hole system as the application of the basic size to the space above the dimension line for the hole or inside measurement.
6. Uses the basic hole system of limit dimensioning two mating machine parts unless the basic shaft system is specified.
7. Defines transition fit between mating parts as a fit which allows relative motion.
8. Contrasts transition fit with interference fit which does not permit relative motion between parts.

LIMIT DIMENSIONING OF MATING MACHINE PARTS - HIERARCHY



Limit Dimensioning of Mating Parts

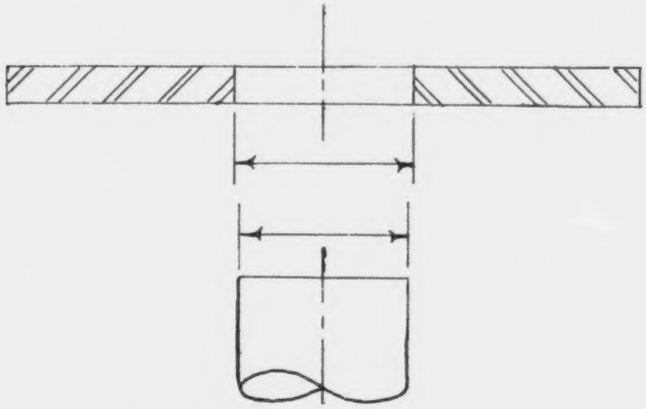
Pretest and Posttest

1. Limit dimension the drawing below given the following information:

   Allowance: - .006

   Maximum clearance: - .010

   Nominal size: - 1 1/2



2. What are the essential differences between transition and interference fits? Indicate these by matching the correct characteristics with the appropriate type of fit.

   Interference ______________________________

   Transition ______________________________

   A. Hole or other space is the larger part.

   B. Shaft is larger than the hole.

   C. Relative motion.

   D. No relative motion.

   E. Parts slide together.

   F. Parts jamb together.

   G. Force necessary for assembly.

3. What system should be used when no specific directions are given?

4. The basic hole system implies that the basic size which is derived from the nominal size is ____.

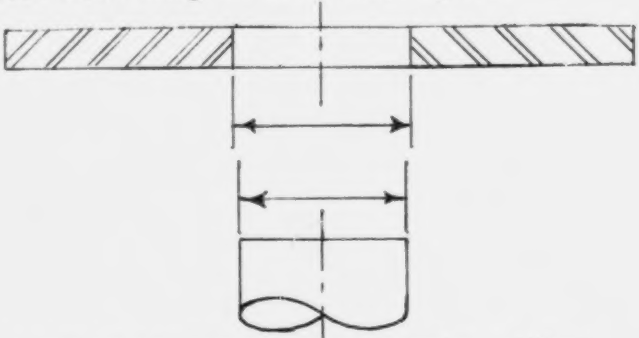
   A. The smallest limit on the hole.

   B. The largest limit on the hole.

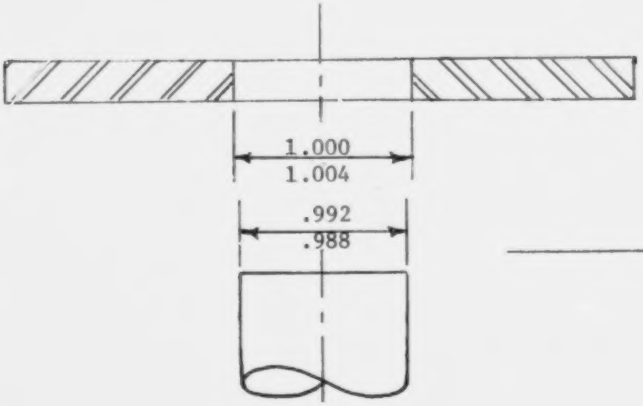
   C. The smallest limit on the shaft.

   D. The largest limit on the shaft.

5. Given a nominal size of 1/2", show where the basic size would be placed in the sketch below using the basic shaft system.



6. Compute the maximum clearance in the following problem:



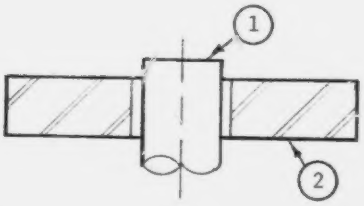
____________________ Ans.

7. Compute the allowance in the drawing for #6 above. ________________ Ans.

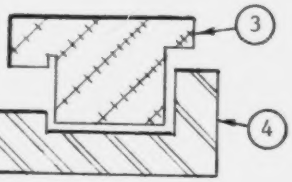
8. Which of the following drawings depicts mating machine parts?

	Yes	No
A. 1 & 2		
B. 3 & 4		
C. 5 & 6		
D. & & 8		
E. 9 & 10		
F. 11 & 12		
G. 13 & 14		
H. 15 & 16		

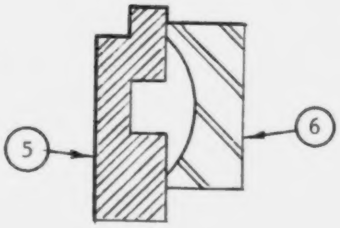
A.



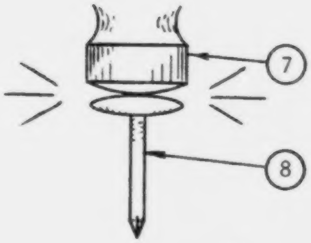
B.



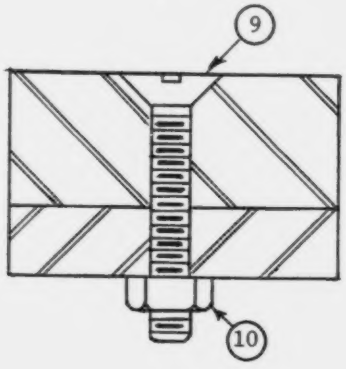
C.



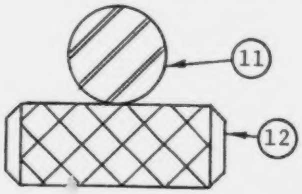
D.



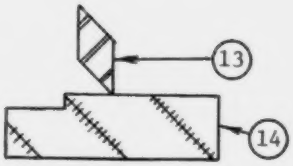
E.



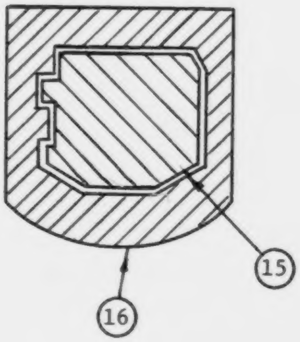
F.



G.

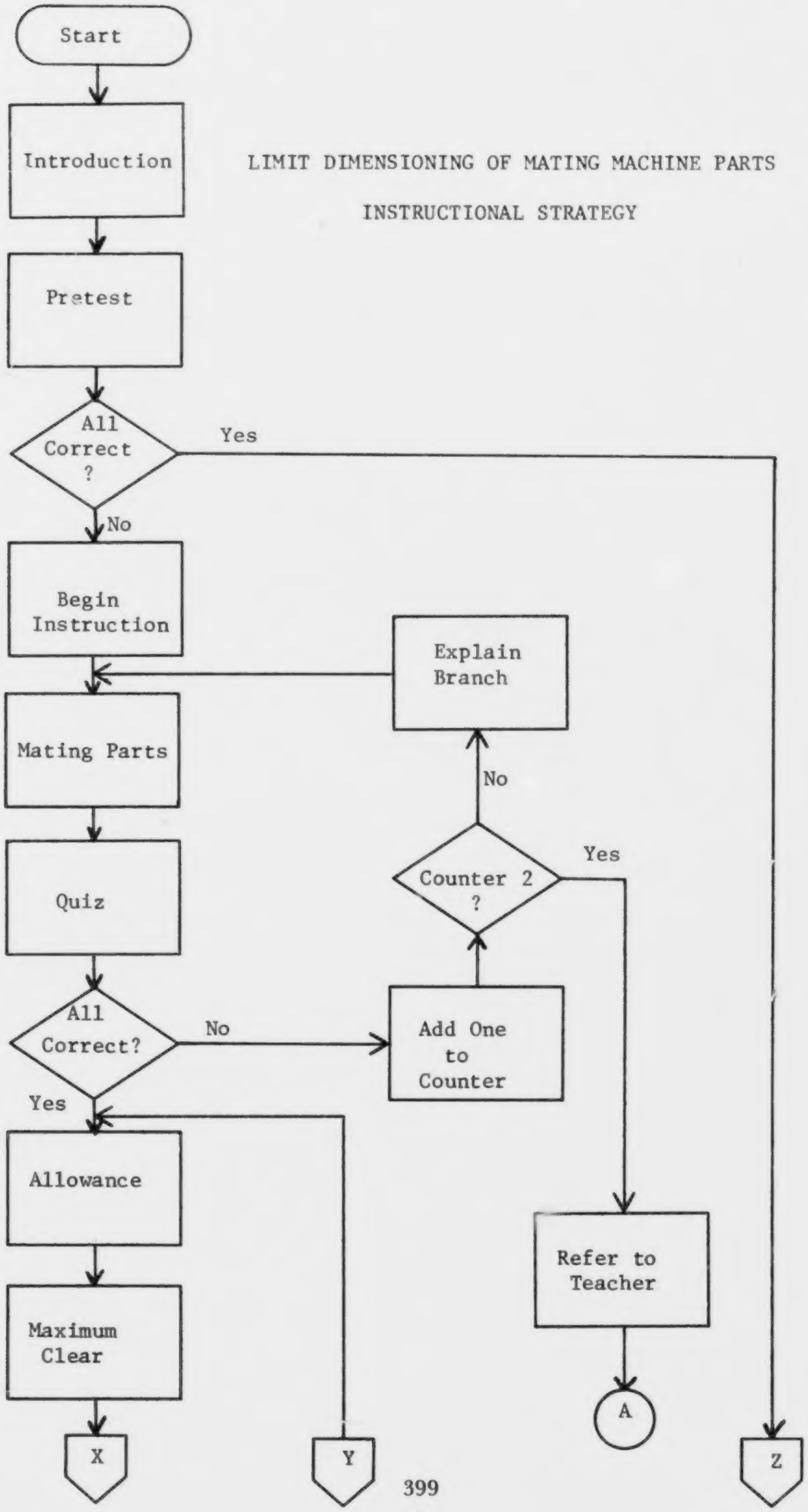


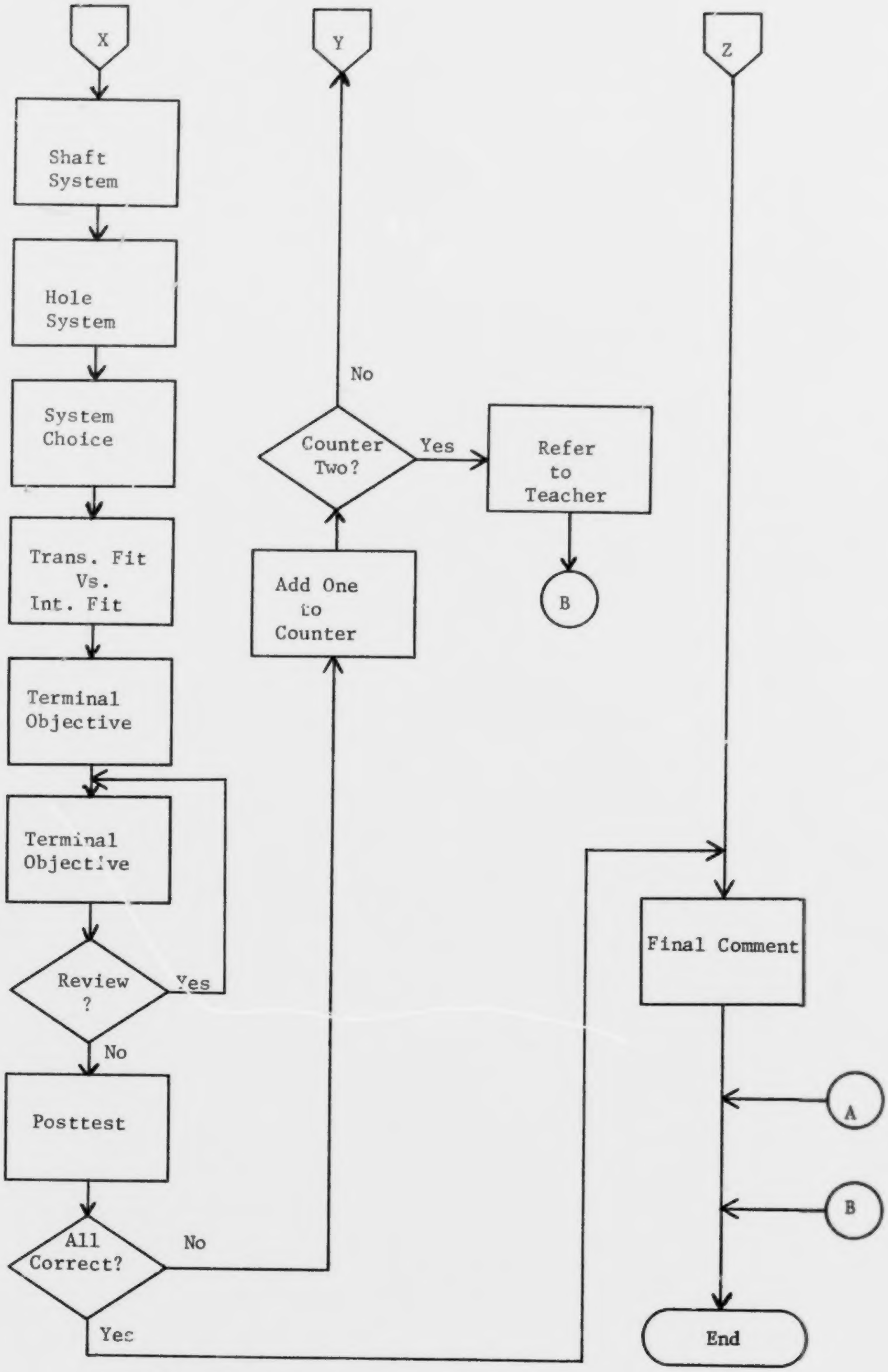
H.



LIMIT DIMENSIONING OF MATING MACHINE PARTS

INSTRUCTIONAL STRATEGY


Start
Introduction
Pretest
All Correct ?
Yes
No
Begin Instruction
Explain Branch
Mating Parts
No
Quiz
Counter 2 ?
Yes
All Correct?
No
Add One to Counter
Yes
Allowance
Maximum Clear
Refer to Teacher
A
X
Y
Z


X
Y
Z
Shaft System
Hole System
System Choice
Trans. Fit Vs. Int. Fit
Terminal Objective
Terminal Objective
Review ?
Yes
No
Posttest
All Correct?
No
Yes
Add One to Counter
Counter Two?
No
Yes
Refer to Teacher
B
Final Comment
A
B
End

Sample Section of Program

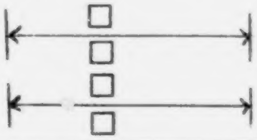
Refer to page 201 in your booklet.

Limit dimension the drawing given the following information:

Allowance: .002

Maximum clearance: .004

Nominal size: 1-1/4



K

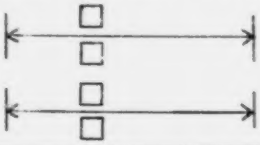
Refer to page 202 of the booklet.

What are the correct limits for those dimensions?

Nominal size: 2-3/4

Allowance: .016

Maximum clearance: .032



K

Your test results indicate that instruction in limit dimensioning of mating machine parts is needed.

The following frames attempt to teach this subject.

S

Comments

This program was also pilot tested with students in the fall of 1970. Validation is scheduled for the 1971 school year.

C. MATERIALS DEVELOPED ELSEWHERE

In the original project proposal, it was envisioned that many CAI materials which existed at that time would be appropriate for use in the MCPS project. Consequently, only a limited number of modular instructional packages would be developed by Project REFLECT.

However, after the project was funded, inquiry into the availability of CAI programs for public school use revealed that very little curriculum had been developed at the secondary school level and even less was available at the elementary level. Meanwhile, close liaison between developers of CAI materials for the IBM 1500 Instructional System was established by the project director, Dr. William M. Richardson, through membership in the Association for the Development of Instructional Systems (ADIS). A second organization, National Association of Users of Computer Applications to Learning (NAUCAL), was formed in 1969. Dr. Richardson actively participated in the planning and implementation of this organization's origin and activities.

As a result of personal contacts, correspondence between the local project and other CAI installations, and membership in professional organizations, certain CAI programs were obtained. The following programs have been acquired and are in the process of being evaluated. It is noted, however, that with the exception of the Kansas City Public Schools' materials, the majority of these CAI programs were developed for use with college students.

Program	Source
Physics	Florida State University
Preskills Scientific Notation Logarithms	University of Texas – Science Research Associates, Inc.
Punctuation	University of Texas – McGraw Hill
Science and Mathematics Modules Introduction to Decimals Density	Kansas City Public Schools

The programs listed below have also been acquired. However, study by project personnel has precluded their use at this time for a number of reasons. Some of these reasons are (a) the method of curriculum development was considerably different from that used at the project, (b) no distinct relationship exists between the MCPS curriculum and the programs, and (c) the project objectives related to those techniques have been fulfilled in other ways.

Program	Source
French Program	Brooklyn College of CUNY Brooklyn, New York
Science and Mathematics Modules Basic Computational Skills Metric System	CAI Laboratory in Math and Science Kansas City, Missouri

Program	Source
Science and Mathematics Modules Relative Error Introduction to Pressure Pressure Continued Earth's Changing Surface Introduction to Scientific Notation Decimal Skills Exponents Fractional Exponents Average Velocity Final Velocity Computation with Scientific Notation Population and Pollution Law of Exponents Frontiers Under the Sea Vectors Three Short Cuts in Multiplication Area Volcanoes Chemistry Introduction to Functions F = ma Boyle's Law Charles' Law Extinct Animals Divisibility Tests Ecology Relative Velocity Basic Skills Drills Gone Fishing	CAI Laboratory in Math and Science Kansas City, Missouri
Learner-Controlled Drill and Practice	IBM Corporation San Jose, California
Physics Simulations	IBM Corporation Yorktown Heights, New York
Fundamentals of Data Processing	IBM Corporation, SRI New York, New York
APL Programs in Physics, Chemistry and Math	Science Research Associates, Inc. Chicago, Illinois
Chemistry Study Modules	The University of Texas Austin, Texas

Following is an excerpt from the Curriculum Development Subplan which describes the process by which materials will be procured, reviewed, adapted, and evaluated.

"E. Survey and Study of CAI Materials Generated By Other Institutions

1. Procurement of CAI Materials.

   The director of the project will make initial contact with other institutions to procure CAI materials. Using the guidelines for selection listed below, the director in conjunction with the teacher specialist in the subject area involved will make decisions about materials to be acquired for perusal.

2. Criteria for Selection.

   The following aspects of procurement and adaptation of available CAI materials will be explored.

   a) Cost.

   b) Constraints on use.

      (1) Copyrights exist on the materials.

      (2) The use of the materials is dependent upon the requirement that no changes be made.

   c) Suitability.

      (1) The materials are appropriate for use within the present MCPS curriculum.

      (2) The materials are appropriate for trial within a course(s) in MCPS curriculum, but material is not presently taught.

      (3) The materials represent the contents for a course not presently taught in MCPS.

   d) Adaptability.

      (1) Changes will need to be made in instructional strategies because of differences in hardware and/or computer language.

      (2) Changes will need to be made in the materials so they will be more useable for MCPS students.

      (3) Consideration will be made as to the time required for adaptation by:

         (a) Curriculum specialist and/or members of his design team
         (b) Technical staff

      (4) Cost of the above adaptations will be determined.

3. Adaptation Procedures.

The teacher specialist and his design team will review the CAI materials procured and will specify plans for their use. Adaptation procedures will follow the development procedures very closely for original CAI packages, as outlined in Section III of this subplan.

4. Evaluation.

Plans for evaluating the effectiveness of the materials will be the same outlined in Section D."

FORM A

CHECKLIST FOR REVIEW OF CAI MATERIALS

Unit ______________________________
Source ______________________________
Date Procured ______________________________
Design Team ______________________________
Reviewer(s) ______________________________

Cost to Project ______________________________
Programming Language ______________________________
Computer ______________________________
Student Time ______________________________
Additional Materials ______________________________

	Acceptable As Is	Needs to be Written Or Revised (Estimated Time)
Terminal Objectives		
Enabling Objectives		
Hierarchy		
Criterion Tests		
Pretest		
Posttest		
Necessary Entering Behaviors		

Comments:

Decision:

D. IMPLEMENTATION INTO CURRICULUM

The introduction of instruction which utilizes the computer can occur in a variety of ways. In MCPS, it is important that both students and educators be aware of the changing educational environment that technology can produce. Through the involvement of the learner and teacher with a modular instructional approach, implementing individualized instruction into existing curriculum is possible. Inherent in the philosophy adopted by Project REFLECT is a dedication to individualized instruction. This is based upon the premise that individual students are unique and possess individual talents. Students learn in many ways.

Materials developed by this project to meet individual needs have been of the modular instructional package format. The basic design employed within this format is the complete development of a concept within a designated curriculum area, rather than an entire course of instruction. The development of concept-related small packages thus allows authors to use and evaluate various CAI techniques, as well as define within a limited range the target population for utilization. It is essential that such materials developed be based upon clearly defined and logically sequenced behavioral objectives. Underlying the presentation of material and the instructional strategies is a commitment to the principle of individualized instruction.

The idea of defining, within a limited range, the target population for utilization may need further clarity. Some mathematical modular instructional packages and their defined target populations are listed on the following page.

Table 1.

Modular Instructional Package	Technique	Curriculum Population
1. Fractions	Drill and Practice	Fourth grade
2. Operation Whole Numbers	Diagnostic, Drill and Practice	Fifth grade
3. Learning About Per Cents	Tutorial	Sixth grade
4. Ratio and Proportion	Tutorial	Algebra II
5. Factoring Polynomials	Tutorial	Algebra I
6. Radical Review	Drill and Practice	Algebra II
7. Slope of the Line	Tutorial	Algebra I
8. Trigonometric Solutions of Right Triangles	Tutorial	Basic Algebra and Geometry
9. Dimensional Analysis	Diagnostic Testing and Instruction	Algebra II
10. Area and Perimeter of Plane Figures	Investigative Inquiry	Ninth grade
11. Volume and Surface Areas of 3-D Figures	Investigative Inquiry	Geometry
12. Integers	Drill and Practice	Eighth grade

Through the use of such packages, it was realized that an inter-curriculum need existed. For example, some tenth grade basic algebra and geometry students needed further instruction in the use of per cents. Some twelfth grade advanced algebra and trigonometry students did not understand the concept of slope. Thus the modular instructional packages listed above have found use in the curriculum areas shown in Table 2 on the following page.

Table 2.

	Secondary Curriculum Areas				
MIP's	Basic Algebra and Geometry	Algebra I	Algebra II	Geometry	Advanced Algebra and Trigonometry
1. Fractions	X	X	X		
2. Operation Whole Numbers*	X	X			
3. Learning About Per Cents	X	X			
4. Ratio and Proportion		X	X	X	X
5. Factoring Polynomials		X	X		X
6. Radical Review		X	X		X
7. Slope of the Line		X	X	X	X
8. Trigonometric Solutions of Right Triangles	X			X	X
9. Dimensional Analysis	X		X		X
10. Area and Perimeter of Plane Figures	X			X	
11. Volume and Surface Areas of 3-D Figures	X			X	
12. Integers	X	X	X		

* This program has also been used with Adult Basic Education students in evening classes during the 1969-70 school year.

The student involved with such programs experiences a different learning atmosphere. He is allowed to progress at his own rate through a learning experience, tailored to meet his needs, interests, and learning style. By design, the programs optimize the likelihood of his attaining the specific objectives. As a result, the student has more individual control over his learning situation and more individual responsibility for the eventual outcome.

The teacher in an individualized setting is primarily responsible for creating and maintaining an atmosphere for such learning to take place. He becomes the manager of the learning environment. Activities now include diagnosing the student's learning difficulties, providing and prescribing additional learning activities and tutoring individual students and/or small groups of students. The role demands from the teacher not only a skill in performing these activities but also a thorough knowledge and understanding of the objectives and strategies employed within each MIP used and the expected outcomes and results. Assistance in obtaining such knowledge is provided by staff members of the CAI Project. To obtain support for this hypothesis, 34 classroom teachers who performed in this capacity during the school year 1970-71 were surveyed on June 11, 1971. Because of the time of year the questionnaire was distributed, only 24 teachers responded. The population was diversified among senior high, junior high, and elementary faculty members. The questionnaire shown on the following page was used to solicit information.

Involved Teacher Questionnaire

Please fill in the following:

1. Approximately how many of your students have used CAI material this year?__________

2. Please rank the CAI techniques from 1 (most important) to 4 (least important) in relation to your subject area. (If you feel unable to do so, please leave this question blank.)

   ________________________________ Subject Area

   __________ drill and practice

   __________ simulation (gaming)

   __________ testing

   __________ tutorial

3. Of what value is CAI to you? Please be specific.

4. Of what value is CAI to your students? Please be specific.

5. What modifications have you made in your planning of lessons (and/or scheduling because of CAI involvement?

6. Describe the activities of a teacher whose students use CAI material.

June 11, 1971

End

Although all remarks were favorable, question six stimulated a variety of interesting comments as shown below:

> "The CAI teacher will spend time scheduling and question answering."
>
> "CAI enables . . . a shifting of the responsibility of learning to the student . . . the student has incredibly much more involvement in the educational process."
>
> "A CAI teacher is much more sociable; he or she spends considerably more time with each student and learns how the individual learns and how best to guide his learning process."
>
> "I have been able to meet more of their individual needs through specializing drills rather than offering general drills."
>
> ". . . it is possible to observe and identify individual problem areas."
>
> "Remind pupils to go on time; check on notes sent back by CAI aide; instruct individuals as needed; inform parents of program."
>
> "Teachers must plan instruction to provide the student with the skills and understandings needed to move from level to level in the drill and practice program."
>
> "The teacher is primarily a proctor and observer of the students. She is able to spot their problem areas easily, and give appropriate assistance. She also provides instruction for those areas where and when needed.'
>
> "The teacher is in an entirely different role . . . few lectures and much more individualization of materials make the teacher think about the student's program and not a class program."

Computer-assisted instruction has been implemented into the curriculum by use of modular instructional packages designed to provide assistance in particular concept areas. The target population originally specified for each MIP has often taken on greater dimensions. The students and teachers using CAI have redefined their respective roles in an educational environment based upon individual needs.

E. VALIDATION AND EVALUATION DATA

Curriculum development and its introduction into the instructional program is followed by validation and later evaluation. This section summarizes the validations of eight modular instructional packages developed during Phases I and II. In addition, two detailed research reports with abstracts and the description of two other evaluation studies conducted during Phase III are included. The latter two studies are based upon materials developed elsewhere.

Plans for evaluation during the next two years are briefly described under Future Research at the end of this section.

1. Validation

The validation process begins with group testing. The group chosen must consist of members of the population for whom the segment was developed and who have the necessary entering behaviors but do not possess the terminal behaviors. These students use the modular instructional package under the conditions for which it was designed. Performance data on all instructional and criterion items is recorded.

Validation is the process which determines whether or not the module teaches what it was designed to teach. If the performance of the group meets the minimum acceptable standards set for validation, the module is valid for that particular population. Standards for validation are determined by the author. In theory, if students possess the necessary entering behaviors and progress through the program, achieving each of the enabling objectives, they will be able to perform on the posttest at the 100 per cent level. However, in many situations, students are enrolled in subjects for which they do not have the entry level. They may be in Algebra II after passing the Algebra I course with a low achievement grade. Others may be in physics or chemistry and not possess the prerequisite mathematics skills. MCPS CAI authors have, therefore, set validation standards based on the population for whom the module was developed. In most cases, these standards state that 80 per cent of the participants will achieve 80 per cent of the objectives.

The following three sections set forth the validation data compiled and analyzed by the project to date. One section is devoted to each of the following subject areas:

Elementary Arithmetic

- Operation Whole Numbers:
  - Addition
  - Subtraction
  - Multiplication

Secondary Mathematics

- Slope of the Line
- Dimensional Analysis
- Ratio and Proportion

Senior High Chemistry and Physics

Use of the Oxidation Potential Table
Writing Chemical Formulas
The Gas Laws
A One-Dimensional Elastic Collision

a) Elementary Arithmetic

Operation Whole Numbers is a CAI package written for elementary school children. This program uses the techniques of diagnostic testing and drill and practice. To ascertain whether or not the program diagnoses the student's level of achievement and prescribes the drill needed, a study was undertaken with third, fourth, fifth, and sixth grade students at Pleasant View Elementary School. In April, 1970, 145 students from the four grades were randomly selected. The Metropolitan Achievement Test, Arithmetic Computation section, was administered with the Elementary Battery being given to the third and fourth graders and the Intermediate Battery to the fifth and sixth graders. Students who achieved at the eighth and ninth stainines, as identified by the test manual, were eliminated from the study. From the remaining group by random selection, 94 students were chosen to take the CAI programs in addition, subtraction, and multiplication. The division program was not complete at that time. The student worked at the terminal 15 minutes or less a day for three days one week and two days the next week over an eight-week period. The data from the study is listed in the following table:

Operation Whole Numbers – Addition, Subtraction, and Multiplication
April–June, 1970

Grade	Number	Pretest Mean	Posttest Mean	Mean Gain	Mean Time (minutes)
3	28	21.4	23.6	2.2	195
4	17	27.2	31.8	4.6	210
5	26	20.8	23.6	2.8	135
6	23	25.8	30.3	4.5	125

b) Secondary Mathematics

In the secondary mathematics field, three modular packages have been tested, each with at least two different student populations.

(1) Slope of the Line is a segment employing the technique of tutorial dialogue. The CAI program begins with an entering behaviors test and, upon its successful completion, follows with instruction. The terminal objectives are:

(a) Given a linear equation, the student will name the slope of the line.

(b) Given the graph of a linear equation, the student will name the slope of the line.

Two groups of students were chosen for validation and the data is listed below:

Validation Group A

Algebra II Students –
Albert Einstein High
Computer Use – January 27 – February 9, 1970

	Pretest	Posttest	Retention Test
Date	1/26/70	As program was completed	3/12/70
Number	27	25	25
Mean Score	.00	.78	.66

Mean Time — 148 minutes (Range 84 — 212 minutes)

Validation Group B

Geometry Students – Ninth Grade
Newport Junior High School
Computer Use – May 12 – May 16, 1970

	Pretest	Posttest	Retention Test
Date	5/9/70	As program was completed	6/4/70
Number	25	25	24
Mean Score	.00	.88	.79

Mean Time — 95 minutes (Range 54 — 180 minutes)

The slope of a line is a concept initially introduced to students in Algebra I classes. All of the students in both validation groups had successfully completed Algebra I. It is interesting to note that only one student in each class was eliminated from the validation study because he showed mastery of the terminal objectives of the program. The Algebra II group was an average high school group of tenth graders who had taken Algebra I in the ninth grade. The geometry students were accelerated mathematics students who had taken Algebra I in the eighth grade.

This CAI program does teach what it purports to teach as shown by the statistics. Students took the first posttest as they completed the program and made mean scores of .78 (Group A) and .88 (Group B). Mean Scores on a retention test, administered after two to three weeks, were .66 (Group A) and .79 (Group B).

It is recommended that the program be used wherever diagnosis shows individual need. Further, the program will be included in year-long research programs in both Algebra I and Algebra II.

(2) Dimensional Analysis is a CAI segment consisting of a diagnostic test which places the student in the program at the lowest objective on which he needs instruction. The terminal objectives of this segment are:

(a) Given one-, two-, and three-dimensional denominate numbers, the student will write equivalent measurements in the same system of measurement.

(b) Given rates, the student will write equivalent rates in the same system of measurement.

These concepts are taught from approximately the third through the ninth grades. However, tests show that students in science and mathematics classes show little proficiency in changing measurement from one unit to another even in the same system of measurement.

As the segment was developed for students who were going into chemistry and physics classes, the first two validation groups were taken from these student populations. The third group and its achievement are discussed following the data.

Validation Group A

Algebra II – Tenth Grade Students
Albert Einstein High
Computer Use – December 10, 1969 – January 9, 1970

	Pretest	**Posttest**	
	12/8/69	1/27/70 –	16 calendar days after last student finished computer program
Number	20	20	
Mean Score	.30	.70	

Mean Time – 59 minutes (Range 29 – 111 minutes)

Validation Group B

Advanced Algebra and Trigonometry
Albert Einstein High School
Computer Use – March 3 – March 20, 1970

	Pretest	**Posttest**
	3/2/70	**4/10/70**
Number	22	22
Mean Score	.46	.76

Mean Time – 47 minutes (Range 31 – 97 minutes)

Validation Group C

Mathematics 10, Einstein High School
November, 1969 – December, 1969

	Pretest 11/10/69	Posttest 12/19/69
Number	19	19
Mean Score	.03	.13

(Range 27 – 71 minutes. However, length of time was not significant. Most of these students were unable to continue in the program as they failed criterion items at crucial points and were not allowed to continue the instruction.)

The program is valid with academic students of Algebra II and Advanced Algebra and Trigonometry classes. In each group the performance on the posttest was significantly different from that on the pretest. Further, in each case at least 75 per cent of the students scored at least 75 per cent on the posttest.

The third group used for validation were the members of a Math 10 class. The Metropolitan Achievement Test, Advanced Battery, had been administered to them and the results showed a mean grade-level of 7.3 on the Computation section and the mean grade-level of 8.6 on the Problem Solving and Concepts section. This class had previously used a program on decimals developed by the Kansas City Public Schools CAI Project and were eager to participate in another CAI program. This program was available and, after discussion with them and their teacher, the students attempted the program.

Dimensional Analysis has criterion test items at the end of each main section. For example, on finishing the initial presentation, which includes many instructional items, the student is given a criterion test with ten items. If at least seven items are not correct, after the initial instructional section and a remedial loop, the student does not continue in the program. In Validation Group C, twelve students could not pass the criterion items on one-dimensional measurements; four more could not pass those on rates, and one student could not pass those on square measurements, leaving only two students who completed the entire program.

It is evident that the program is not valid for Validation Group C. If the concepts and skills of the program are to be taught to students of this mathematical ability, the approach, vocabulary and items would need to be simplified.

(3) Ratio and Proportion, a two-part program, the first part of which is tutorial, has the terminal objective of:

> Given 10 word problems illustrating direct, joint, inverse, and combined variation, the student names the kind of variation described in at least nine problems.

The second section allows the student to choose his own method of acquiring the terminal behavior. He may view proportions with illustrations to "discover" the method of setting up problems, or he may get instruction through tutorial dialogue. In either case, he may test himself at any point and as many times as he wishes on any or all kinds of problems involving variation.

The terminal objective of the total package is:

> Given four word problems involving direct, joint, inverse, and combined variation, the student sets up and solves the problems.

Validation groups consist of one summer school class of 14 students taking a voluntary noncredit course, math skills for chemistry and physics, and one class of advanced algebra and trigonometry students during the regular school year. Data for each group follows:

Validation Group A

Summer School – Math Skills for Science Students
June 26 – July 18, 1969

	Pretest	Posttest
Number	13	13
Mean Score	.19	.81

Mean Time – 116 minutes (Range 67 – 214 minutes)

Validation Group B

Advanced Algebra and Trigonometry
Computer Use – March 10 – March 27, 1970

	Pretest	Posttest
Number	22	22
Mean Score	.32	.86

Mean Time – 91 minutes (Range 65 – 182 minutes)

This program has been validated only with above average students. Only four of the students in Validation Group B had not completed Algebra II. In the summer class, six students achieved 100 per cent, four 75 per cent, and the remainder 50 per cent. Therefore, 77 per cent of the students made at least 75 per cent on the posttest. The second group's achievement exceeded that of the first group's. The segment has been found to be valid with students with a background of two or three years of academic mathematics.

c) Senior High Chemistry and Physics

High school science is a third area of curriculum development in which data has been collected.

(1) The Use of the Oxidation Potential Table is a senior high school chemistry program which uses the instructional technique of drill and practice. The skill taught in this program is necessary so that students can predict if spontaneous chemical reactions will occur. After reviewing the rules for using the table, the student predicts if reactions occur for pairs of substances selected by the program author. Following completion of this brief section, he is asked to select from a table pairs of substances that he believes will react spontaneously. At the end of each cycle, he may choose additional practice.

A group of 35 Einstein High School chemistry students achieved a mean score of 60 per cent on the five-item pretest, but no one made 100 per cent, so the group was registered for the CAI program. On the posttest, 29 students answered correctly all five items. Therefore, 83 per cent of the student achieved 100 per cent after using the drill and practice module, and the remaining six students made 80 per cent on the posttest. The mean completion time was 13.7 minutes.

(2) Basic Chemical Formula Writing Skills is a senior high school program employing tutorial dialogue for instruction. Its terminal objectives are: (a) Given the formula of a compound, state the chemical name of the compound; (b) Given the name of a compound, write the formula of that compound. A diagnostic pretest on both the terminal and enabling objectives permits the student to by-pass instruction on any objectives for which he has already acquired the behaviors.

Six chemistry classes at Einstein High School were used to select the validation group. One hundred and sixty-six students took the pretest and 109 students failed the items on both objectives. From this latter group, 72 students were randomly selected to participate in the validation study. Following completion of the program, a posttest of eight items, four on each terminal objectives, was given. Traditionally, chemistry teachers feel that male and female students perform differently, so all the following data reflect this bias:

Analysis of Correct Responses

Group	**Number**	**Pretest Mean**	**Posttest Mean**
Male	37	1.51	6.81
Female	35	1.80	6.80
Total	72	1.65	6.80

Student Attainment of Both Objectives

		Total Objectives Possible	Number of Objectives Attained	Percent of Objectives Attained
Male	37	74	64	86.5
Female	35	70	61	87.2
Total	72	144	125	86.9

A standard for validation of 75 per cent of the students was set for this package. The entire student group exceeded the standard on each objective and on the combined results, with 83 per cent of the students having 85 per cent of the criterion items correct. Of interest to chemistry teachers may be the information that there was no significant difference at the .001 level between the scores of male and female students.

(3) The Gas Laws consist of a series of CAI programs which enable the student to "discover" the basic relationships between the properties of gases as stated within Boyle's Law, Charles' Law, and the Temperature-Pressure relationship. Three simulations with related problem drills for each have been developed using APL (A PROGRAMMING LANGUAGE).

To determine the effectiveness of these CAI programs, a validation study was conducted, using chemistry students at Albert Einstein High School. As instruction on the properties of gases and on the gas laws had occurred approximately three months prior, a pretest of nine questions, three on each gas relationship, was given to a chemistry class of 23 students. Ten students were identified who had not acquired any of the terminal behaviors. The other thirteen students were used as a control group, only for the purpose of ascertaining whether a significant difference between pretest and posttest scores might occur because of the use of the identical test in each case. The students selected for the CAI program received instruction for 25- to 35-minute periods for each of the two following days. On the fourth day, all 23 students were given the pretest with the following results:

Group	Number	Pretest Mean Score	Posttest Mean Score	Mean Gain
CAI	10	2.10	7.00	4.90
Non-CAI	13	5.77	6.31	.54

Mean Time – on computer terminals – 62.5 minutes (Range 55 – 70 minutes)

A standard of validation of 80 per cent of the students achieving 80 per cent of the terminal behaviors was set for this MIP. The results showed that 90 per cent of the students had 89.6 per cent of the questions correct. Non-CAI students made no significant gain between the pretest and posttest, eliminating the possibility that the test itself affected the results.

(4) A One-Dimensional Elastic Collision provides a simulated environment for student investigation. This program permits the student to manipulate the environment so that he "discovers" that, in the system with which he is working, momentum is conserved.

Twenty-nine physics students at Albert Einstein High School spent one class period of 55 minutes investigating momentum changes in a system. None of these students had already attained the terminal objectives of the program. Following the use of the computer simulation, these students achieved a mean score of 80.2 per cent on the posttest.

2. Evaluation

The effectiveness and efficiency of CAI programs when compared with traditional instruction and measured by standardized norm-referenced tests is one aspect of evaluation. A second important area is the measure of receptivity by students and teachers of an innovative method of presenting instruction.

It is impractical to have completed extensive research in a three-year period when, within that time frame, planning, staff training, curriculum development, and validation had to be initiated and completed. In this section, therefore, there are two research reports, one on effectiveness and a second on attitudes, which were conducted and written prior to July, 1971. Two designs, which were formulated to evaluate CAI materials developed by other installations, are also described. A number of short-term and full-year studies are in process as the project begins its fourth year. Certain of these studies are also described at the end of this Evaluation section.

a) Research Reports

(1) Measuring Computer-Assisted Instruction Effectiveness in Algebra II

An abstract and report on a study conducted by Thomas E. Robinson and Eleanor Lautenschlager at Albert Einstein High School follow on the next page.

Abstract

During the school year 1970-1971 four of nine Algebra II classes at Albert Einstein High School, Kensington, Maryland, participated in a study designed to measure the effectiveness of Computer-Assisted Instruction in Algebra II. Two experienced teachers taught the involved classes, with each teacher having a control and an experimental class. In the experimental classes (N=44) the teacher did much of the instruction, utilizing available CAI Modular Instructional Packages when diagnosis revealed further tutorial assistance was necessary. The control classes (N=45) were completely teacher taught. Because of the manner in which Computer-Assisted Instruction was used, the E and C classes were subdivided further. Only those students whose pretest scores fell below the group median (identical for E and C) were considered in this study. The findings are thus based upon data obtained from these subgroups. The Blyth Second-Year Algebra Test was the measuring instrument for the pretest (10/19/70) and the midyear test (1/29/71).

MIDYEAR TEST FINDINGS

	Experimental (N=22)	Control (N=22)
Pretest	Mean = 14.73 σ = 2.99	Mean = 14.82 σ = 2.08
Posttest	Mean = 21.50 σ = 4.24	Mean = 18.95 σ = 4.07
Mean Gain	+6.77	+4.14
Std. Deviation (gain)	σ = 3.15	σ = 4.14
t-score (gain)	9.86	4.58
Significance level	$<.05$	$<.05$

Difference on Pretest scores (E vs. C)	t = -0.11	no significance
Difference on Posttest scores (E vs. C)	t = 2.32	significance level $<.05$

Findings of this study indicate:

1) No significant difference existed between the groups on Pretest scores.

2) Both groups had significant gains between Pretest and Posttest scores.

3) The experimental students (those exposed to CAI for remediation) had significantly greater gain between Pretest and Posttest scores than those students not exposed to CAI.

Introduction

Background

The objective of this report is to make public the design, procedures, and preliminary findings of an Algebra II evaluation study conducted by the Computer-Assisted Instruction Project of the Montgomery County Public Schools. Four of the nine Algebra II classes at Albert Einstein High School, Kensington, Maryland, during the school year 1970-1971 participated in this study.

Two experienced Montgomery County teachers taught the involved classes, with each teacher having a control and experimental class. The classes were assigned to the experimental or control methods solely on the basis of computer availability.

This study is a comparison of achievement scores between Algebra II students who used CAI, and those whose instruction did not include CAI. The control (C) classes received teacher instruction and studied Algebra II without CAI assistance. In the experimental (E) classes the teacher did much of the instruction, utilizing CAI Modular Instructional Packages when diagnosis revealed further tutorial assistance was necessary. Because of this remedial usage of CAI material, some students in the experimental classes would have no exposure to CAI assistance. Consequently, both the E and C designated classes were further subgrouped. Only those students whose pretest scores fell below the group median (18 raw score points; identical for E and C) were considered in this study. This subgrouping allowed for the evaluation of Computer-Assisted Instruction effectiveness with comparable achievement level students (See Table 1, p. 5, E vs. C - pretest scores).

CAI materials used were written by the Computer-Assisted Instruction Project Mathematics Design Team except as otherwise noted. Students in the experimental group used the following Modular Instructional Packages:

Factoring Polynomials
Slope of the Line
Radical Review
Ratio and Proportion
Scientific Notation (University of Texas)
Problem Solving
Drills on Integer Computations

Problem

Some research (Atkinson and Suppes, 1968) [1] indicates that slower students particularly benefit from the use of CAI materials. Students of abilities commonly referred to as average (on the basis of IQ, standardized test scores, previous grades, etc.) composed the four participating classes; however, the E and C subgroups studied were formed from the lower 50% of these classes. It was therefore hypothesized that those students exposed to CAI material for remediation would have significantly greater gains from pretest scores to posttest scores (or midyear test scores as herein reported) than those students not exposed to Computer-Assisted Instruction.

The evaluation study was designed in April, 1970, and was initiated the following September.

Method

Design

Ss - students of Algebra II

E	(N=22)	O_1	X	O_2	X	O_3
C	(N=22)	O_1		O_2		O_3

X - Algebra II concepts aided by CAI Modular Instructional Packages

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[1] Atkinson, Richard C. and Suppes, Patrick, An Automated Primary - Grade Reading and Arithmetic Curriculum for Culturally Deprived Children. Stanford University, California, 1968. (ERIC)

O_1, O_2, O_3 - Blyth Second-Year Algebra Test[2] given as pretest, midyear test and scheduled for the posttest.

Range of Pretest scores:

Experimental	9 to 18
Control	11 to 18

Selection

Of the nine Algebra II classes at Albert Einstein High School, Kensington, Maryland, four classes being taught by two experienced Montgomery County teachers constituted the original pretested subjects. Each teacher had a control class (completely teacher taught) and an experimental class (CAI remediation). These assignments were based solely on computer availability. The E and C classes were further subgrouped based upon pretest scores, with those students whose scores fell below the group median being considered members of this study.

Planned Procedures

1. Pretest to be administered - October 19, 1970.
2. Instruction - Experimental group will receive a combination of teacher instruction and CAI review in Algebra II concepts. The control group will be entirely teacher taught.
3. Administer midyear test - January 29, 1971 - Compute means and make comparisons. T-test will be used to compute significant differences.
4. Continue instruction.
5. Administer posttest - June 4, 1971 - Compute means and make comparisons. T-test will be used to compute significant differences.

Assumptions

1. CAI will emphasize the "A" for "Assisted," and will be used to aid or assist the teacher.

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[1] Blyth, M. Isobel, Blyth Second-Year Algebra Test - Manual. Revised Edition: Michigan State University, Harcourt, Brace and World, Inc., 1966.

2. Teachers involved in the study will be experienced (at least 2 years) in the teaching of Algebra II.

Instrument

The Blyth Second-Year Algebra Test was used as the measuring instrument. The following information has been obtained regarding test validity and reliability.

1. A guessing distractor is included within this test. This takes the form of a DK (Don't Know) multiple choice option. ".... the contamination of student's scores by wild guessing is less than it would be if the DK options were not included." (Blyth, p.5)
2. Validity has been assessed in respect to content validity as attested to by "authoritative judges and by a consensus of current practices." (Blyth, p.14)
3. Reliability has been measured by a split-halves (odd-even) procedure. A calculation of the standard error of measurement is included. Results of these measurements show that "..... in two out of three possible administrations of the test, a student's true raw score should not be expected to differ from his obtained raw score by more than 3 raw score points." (Blyth, pp.14, 15)

Definitions

Independent Variable: CAI used to aid the teacher in the instruction of Algebra II.

Dependent Variable: Student scores, range of improvement (gain).

Operational Definition: Group achievement is a calculated difference between:

a) Pretest and midyear test means and/or

b) Pretest and posttest means

Results

Table 1. Determination of Difference
Experimental vs. Control - Pretest Scores

	Pretest Scores
Experimental (N=22) Mean - SD	14.73 $\sigma = 2.99$
Control (N=22) Mean - SD	14.82 $\sigma = 2.08$
Difference *	.09
T-score on Difference	$t = -0.11$ d.f. = 42
Significance Level	No Significance

* Difference calculated as control mean minus experimental mean.

Table 2. Determination of Difference
Pretest vs. Midyear Test Scores for Experimental and Control Groups

	Experimental (N=22)	Control (N=22)
Pretest Mean - SD	14.73 $\sigma = 2.99$	14.82 $\sigma = 2.08$
Midyear Test Mean - SD	21.50 $\sigma = 4.24$	18.95 $\sigma = 4.07$
Mean Gain - SD	+6.77 $\sigma = 3.15$	+4.14 $\sigma = 4.14$
T-Score (gain)	t = +9.86 d.f. = 42	t = +4.58 d.f. = 42
Significance Level	$< .05$	$< .05$

Table 3. Determination of Difference
Experimental vs. Control - Midyear Test Scores

	Midyear Test Scores
Experimental (N=22) Mean - SD	21.50 $\sigma = 4.24$
Control (N=22) Mean - SD	18.95 $\sigma = 4.07$
Difference **	2.55
T-Score on Difference	$t = 2.32$ d.f. = 42
Significance Level	$< .05$

** Difference calculated as experimental midyear mean minus control midyear mean.

Discussion

It was predicted that those students exposed to Computer-Assisted Instruction for remediation would have significantly greater gains from pretest to posttest results (or midyear test results as herein reported) than those students not exposed to Computer-Assisted Instruction. This hypothesis has been substantiated.

The experimental group had a mean gain of 6.77 ($t=9.86$; $<.05$) as compared to a mean gain for the control group of 4.14 ($t=4.58$; $<.05$). Although both groups gained significantly (See Table 2., p.6) from pretest to midyear test results, the experimental group had a significantly greater gain (See Table 3., p.7).

A fundamental assumption of this study was that the involved teachers have at least two years experience in the teaching of Algebra II. This standard was maintained through February 1, 1971, at which time one of the involved teachers was selected for a teacher specialist position. A qualified replacement was obtained; however, this new teacher had no teaching experience. Since the preformed assumption could no longer be adhered to, and considering the uncontrollable factors that might be introduced with this change of personnel, the Algebra II evaluation was terminated at midyear. The results and findings of this study may thus be considered conclusive.

The suggestion that Computer-Assisted Instruction may be a valuable tool for remediation as well as for primary tutorial introduction of material will be considered in evaluation conducted by this project in the near future.

(2) Evaluation of Student Attitude Questionnaires

A second research study was conducted by Thomas E. Robinson and Eleanor Lautenschlager based on the findings related to student attitudes. The abstract and the report appear on the following page.

Abstract - Evaluation of Student Attitude
QUESTIONNAIRE "HOW DO YOU FEEL ABOUT......?

"To learn new material" is the most important use of Computer-Assisted Instruction, according to the mean rankings of more than 300 high school mathematics students surveyed.

Uses of CAI (N=335)

MOST IMPORTANT	MEAN RANKING	USE
1st	2.27	B - to learn new material
2nd	2.77	E - to practice on difficult material
3rd	2.87	C - to review old material
4th	4.09	F - to do computations
5th	4.82	A - to take tests
6th	5.19	G - to write programs
7th	6.03	D - to play games

LEAST IMPORTANT

The majority (57.2%) of the students surveyed expressed favorable attitudes toward CAI. Those students exposed to CAI had more favorable attitudes related to the questions, "How do you feel about mathematics?" and "How do you feel about Computer-Assisted Instruction?" than those students not exposed to CAI.

Favorable Atitudes
CAI and Non-CAI Students

	CAI (N=176)	Non-CAI (N=175)
Yourself?	50.2%	56.0%
School?	58.5%	62.8%
Mathematics?	60.0%	57.8%
CAI?	61.4%	53.0%

Favorable Attitudes
Total Population Surveyed

	(N=351)
Yourself?	53.1%
School?	60.7%
Mathematics?	58.9%
CAI?	57.2%

Students in 16 mathematics classes at Albert Einstein High School, Kensington, Maryland, were surveyed on April 6, 1971. Eight classes exposed to CAI were matched (i.e., course content, achievement level) with eight classes not exposed to CAI. Questions in the form of semantic differentials were used to ascertain attitudes about 1) themselves as students, 2) school in general, 3) mathematics (the subject), and 4) Computer-Assisted Instruction. In addition, the students were asked to rank from most important to least important the uses of CAI.

The attitude measuring instruments used within this study were designed by Eleanor Lautenschlager, Mathematics Design Team Member and Thomas E. Robinson, Teacher Specialist in Curriculum.

The extensive evaluation document of this study is available on request.

INTRODUCTION - BACKGROUND

To evaluate Computer-Assisted Instruction's effectiveness in a realm other than achievement, the questionnaire entitled, "How do you feel about ...?" was developed. The questionnaire was designed using a mixed format - the Semantic Differential and a Preference Ordinal Scale - to solicit student attitudes about:

1) themselves as students
2) school in general
3) mathematics (the subject)
4) Computer-Assisted Instruction

In addition to these areas of concentration students were asked to rank from most important to least important these uses of CAI:

(A) To take tests
(B) To learn new material
(C) To review old material
(D) To play games (like chess)
(E) To practice on difficult material
(F) To do computations (like square root)
(G) To write programs for the computer

Design

Approximately 350 students in mathematics classes at Albert Einstein High School were surveyed April 6th, 7th and 20th, 1971. It was necessary to use three days because of individual teacher scheduling: the survey itself took no more than 15 minutes. Those classes exposed to CAI were matched with classes not exposed to CAI and of similar achievement levels.

The following classes were surveyed:

Class Subject	Number of Classes		Grades
Consumer Mathematics*	1	Non-CAI	11-12
Basic Algebra and Geometry	1	CAI	10
Algebra I	2	1 CAI,1 Non-CAI	10
Algebra II	4	2 CAI,2 Non-CAI	10-11
Advanced Algebra and Trigonometry	4	2 CAI,2 Non-CAI	12
Geometry	4	2 CAI,2 Non-CAI	11

Instrument

Following is a copy of the questionnaire.

*Because all of the Basic Algebra and Geometry classes had been exposed to CAI, a Consumer Mathematics was selected for comparison.

Questionnaire: 2 pages

INFORMATION: Boy___ Girl___ Present Math Class
Alg. I___ Alg. II___ Geo.___ Trig.___
Consumer Math___

Write a 1 beside what you think is the most important use of Computer Assisted Instruction (CAI), then 2 beside the next most important use, and so on, with 7 beside the least important use of CAI.

______(A) To take tests

______(B) To learn new material

______(C) To review old material

______(D) To play games (like chess)

______(E) To practice on difficult material

______(F) To do computations (like square root)

______(G) To write programs for the computer

CIRCLE the letter that corresponds to any of the above that you have used.

A B C D E F G

What kind of work would you like to do, after you finish your schooling?

____

HOW DO YOU FEEL ABOUT...............?

DIRECTIONS: Place an X in the blank that best expresses your feelings or reactions. For example:

How Do You Feel About School? I think school is..........

INTERESTING	____	_X_	____	____	____	BORING
EASY	____	____	____	____	_X_	DIFFICULT

The X marks above indicate that this person feels school is INTERESTING, but not VERY INTERESTING, and that school is VERY DIFFICULT. If an X had been placed in the middle blank, it would mean NO FEELING for that pair of words about school.

Read each pair of words CAREFULLY and give YOUR FIRST IMPRESSION. Work quickly. Do not compare them to other words. We want your TRUE IMPRESSIONS about each pair.

How Do You Feel About Yourself, as a STUDENT? I think I am...............

SUCCESSFUL	____	____	____	____	____	UNSUCCESSFUL
AIMLESS	____	____	____	____	____	MOTIVATED
IMPORTANT	____	____	____	____	____	UNIMPORTANT
SAD	____	____	____	____	____	HAPPY

How Do You Feel About School? I think school is ....

IMPORTANT	____	____	____	____	____	UNIMPORTANT
UNNECESSARY	____	____	____	____	____	NECESSARY
BENEFICIAL	____	____	____	____	____	HARMFUL
WORTHLESS	____	____	____	____	____	VALUABLE
INTERESTING	____	____	____	____	____	BORING
DIFFICULT	____	____	____	____	____	EASY
UNDERSTANDABLE	____	____	____	____	____	MYSTIFYING
UNPLEASANT	____	____	____	____	____	PLEASANT

How Do You Feel About Mathematics? I think Math. is ....

IMPORTANT	____	____	____	____	____	UNIMPORTANT
NECESSARY	____	____	____	____	____	UNNECESSARY
HARMFUL	____	____	____	____	____	BENEFICIAL
WORTHLESS	____	____	____	____	____	VALUABLE
INTERESTING	____	____	____	____	____	BORING
EASY	____	____	____	____	____	DIFFICULT
MYSTIFYING	____	____	____	____	____	UNDERSTANDABLE
PLEASANT	____	____	____	____	____	UNPLEASANT

How Do You Feel About Computer Assisted Instruction? I think CAI is.....

UNIMPORTANT	____	____	____	____	____	IMPORTANT
NECESSARY	____	____	____	____	____	UNNECESSARY
HARMFUL	____	____	____	____	____	BENEFICIAL
WORTHLESS	____	____	____	____	____	VALUABLE
BORING	____	____	____	____	____	INTERESTING
EASY	____	____	____	____	____	DIFFICULT
UNDERSTANDABLE	____	____	____	____	____	MYSTIFYING
UNPLEASANT	____	____	____	____	____	PLEASANT

↓↓↓↓THE END↓↓↓↓

Thank you for your cooperation.

Evaluative Techniques

The uses of CAI were ranked according to an ordinal scale. Given a seven item list the students were asked to place a *1* in front of the use which to them was the *most* important use of CAI, a *2* by the next most important use, and to continue until they finally place a *7* in front of what they identified as the *least* important use. In the topic of *Findings*, you will find the average rank value of the seven uses and a reordering of the uses from most important to least important for the CAI students, the non-CAI students, and the total group.

The four remaining questions soliciting attitudes about themselves as students, school, mathematics, and Computer-Assisted Instruction were semantic differentials. The pairs of verbal opposites or polar words used in this study were selected from the evaluative category compiled by Charles E. Osgood (1967).[1] In each pair, one of the words has a distinctly positive connotation, and the other a negative connotation.

PAIRS OF WORDS USED IN THIS STUDY

Positive		Negative
Important	-	Unimportant
Necessary	-	Unnecessary
Beneficial	-	Harmful
Valuable	-	Worthless
Interesting	-	Boring
Easy	-	Difficult
Understandable	-	Mystifying
Pleasant	-	Unpleasant
Successful	-	Unsuccessful
Motivated	-	Aimless
Happy	-	Sad

1./ Osgood, Charles E., Suci, George, and Tannenbaum, Percy H. *The Measurement of Meaning*, University of Illinois Press; Urbana, Illinois, 1967

Each pair of words was separated by 5 blanks. The evaluation of these blanks took the following form:

Favorable - an X placed in either of the two blanks closest to the (+) positive polar word

Neutral - an X placed in the middle (third) blank indicating no attitude

Unfavorable - an X placed in either of the two blanks closest to the (-) negative polar word.

Example:

How do you feel about yourself, as a student? I think I am...........

(Rated Favorable)	Successful	____	X	____	____	____	Unsuccessful
(Rated Neutral)	Aimless	____	____	X	____	____	Motivated
(Rated Unfavorable)	Important	____	____	____	____	X	Unimportant

In line with Osgood's Recommendations the pairs of words were listed so that the positive words appeared on the left 50% of the time and on the right 50% of the time.

Hypotheses

1. Those students exposed to CAI will rank as the most important use of CAI item B To learn new material.
2. Those students not exposed to CAI will rank as the most important use of CAI item E To practice on difficult material.
3. Those students exposed to CAI will rank as the least important use of CAI item D To play games.
4. Those students not exposed to CAI will rank as the least important use of CAI item A To take tests.

5. Those students exposed to CAI will have a higher percentage of favorable attitudes towards the question, "How do you feel about yourself, as a student?" than those students not exposed to CAI.
6. Those students exposed to CAI will have a higher percentage of favorable attitudes towards the question, "How do you feel about school?" than those students not exposed to CAI.
7. Those students exposed to CAI will have a higher percentage of favorable attitudes toward the question, "How do you feel about mathematics" than those students not exposed to CAI.
8. Those students exposed to CAI will have a higher percentage of favorable attitudes toward the question "How do you feel about Computer-Assisted Instruction?" than those students not exposed to CAI.

Findings:

Table 1.

USES OF CAI (CAI GROUP)

	A (Tests)	B (New Material	C (Review)	D (Games)	E (Practice)	F (Computations)	G (Programs)	
Basic Algebra and Geometry	4.90	3.40	2.60	5.10	3.00	4.20	4.80	N = 10
Algebra II	4.46	2.80	2.06	6.48	2.46	4.08	5.46	N = 50
Algebra I	5.53	1.67	2.67	5.87	2.80	4.01	5.40	N = 15
Trigonometry	4.76	2.59	2.47	5.47	3.22	4.47	5.04	N = 49
Geometry	4.19	1.88	2.63	6.37	2.86	4.44	5.63	N = 43
Average of columns	4.77	2.47	2.49	5.86	2.87	4.24	5.27	
								TOTAL N = 167

Table 2.

USES OF CAI (NON-CAI GROUP)

	A (Tests)	B (New Material)	C (Review)	D (Games)	E (Practice)	F (Computations)	G (Programs)	
Consumer Math	4.79	1.86	3.71	5.86	3.00	4.14	4.64	N = 14
Algebra II	4.78	2.32	3.10	6.32	2.54	3.98	4.98	N = 41
Algebra I	4.38	1.86	3.38	6.24	2.67	3.90	5.62	N = 21
Trigonometry	4.84	2.16	2.71	6.33	2.44	4.16	5.36	N = 45
Geometry	5.55	2.17	3.36	6.26	2.66	3.51	4.92	N = 47
Average of columns	4.87	2.07	3.25	6.20	2.66	3.94	5.10	
								TOTAL N = 168

Table 3.

USES OF CAI (TOTAL GROUP)

	A (Tests)	B (New Material)	C (Review)	D (Games)	E (Practice)	F (Computations)	G (Programs)	
Consumer Math Non-CAI	4.79	1.86	3.71	5.86	3.00	4.14	4.64	N = 14
Basic Alg. & Geom. CAI	4.90	3.40	2.60	5.10	3.00	4.20	4.80	N = 10
Algebra II Non-CAI	4.78	2.32	3.10	6.32	2.54	3.98	4.98	N = 41
Algebra II CAI	4.46	2.80	2.06	6.48	2.46	4.08	5.46	N = 50
Algebra I Non-CAI	4.38	1.86	3.38	6.24	2.67	3.90	5.62	N = 21
Algebra I CAI	5.53	1.67	2.67	5.87	2.80	4.01	5.40	N = 15
Trigonometry Non-CAI	4.84	2.16	2.71	6.33	2.44	4.16	5.36	N = 45
Trigonometry CAI	4.76	2.59	2.47	5.47	3.22	4.47	5.04	N = 49
Geometry Non-CAI	5.55	2.17	3.36	6.26	2.66	3.51	4.92	N = 47
Geometry CAI	4.19	1.88	2.63	6.37	2.86	4.44	5.63	N = 43
Average of Columns	4.82	2.27	2.87	6.03	2.77	4.09	5.19	

TOTAL N = 335

Table 4.

USES OF CAI (RANKINGS)

MOST IMPORTANT

	Total Group	CAI	Non-CAI
1st.	2.27 - B to learn new material	2.47 - B to learn new material	2.07 - B to learn new material
2nd.	2.77 - E to practice on difficult material	2.49 - C* to review old material	2.66 - E* to practice on difficult material
3rd.	2.87 - C to review old material	2.87 - E* to practice on difficult material	3.25 - C* to review old material
4th.	4.09 - F to do computations	4.24 - F to do computations	3.94 - F to do computations
5th	4.82 - A to take tests	4.77 - A to take tests	4.87 - A to take tests
6th.	5.19 - G to write programs	5.27 - G to write programs	5.10 - G to write programs
7th.	6.03 - D to play games	5.86 - D to play games	6.20 - D to play games

LEAST IMPORTANT

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* Note that these two columns differ only in the reverse ordering of uses C and E. The author had intended to make the distinction between review (recollection of concepts) and practice on difficult material (strengthening identified weaknesses); however, the student may perceive review of old material (C) to be necessary because it is difficult (E).

Table 5.

ATTITUDES OF THE CAI GROUP AND THE NON-CAI GROUP

How do you feel about -	Favorable		Neutral		Unfavorable	
	CAI	Non-CAI	CAI	Non-CAI	CAI	Non-CAI
Yourself as a student?	50.2%	56.0%	28.2%	29.4%	21.6%	14.6%
School?	58.5%	62.8%	20.5%	17.2%	21.0%	20.0%
Mathematics?	60.0%	57.8%	21.3%	18.6%	18.7%	23.6%
Computer-Assisted Instruction?	61.4%	53.0%	26.2%	32.7%	12.4%	14.6%

CAI: N = 176
Non-CAI N = 175

Table 6.

ATTITUDES OF TOTAL POPULATION SURVEYED

How do you feel about -	Favorable	Neutral	Unfavorable
Yourself as a student?	53.1%	28.8%	18.1%
School?	60.7%	18.8%	20.5%
Mathematics?	58.9%	19.9%	21.2%
Computer-Assisted Instruction?	57.2%	29.5%	13.3%

N = 351

Conclusions

Hypothesis 1.

Those students exposed to CAI will rank as the most important use of CAI item B To learn new material.

- Based upon the findings (See Tables 1. and 4., pages 8 and 10) this hypothesis is substantiated. The CAI group rated item B as the most important use with an average ranked position of 2.47.

Hypothesis 2.

Those students not exposed to CAI will rank as the most important use of CAI item E To practice on difficult material.

- Based upon the findings (See Tables 2. and 4., pages 8 and 10) this hypothesis is not substantiated. The non-CAI group ranked item B as the most important use of CAI, with an average ranked position of 2.07; however, item E was ranked second with 2.66.

Hypothesis 3.

Those students exposed to CAI will rank as the least important use of CAI item D To play games.

- Based upon the findings (See Tables 1. and 4., pages 8 and 10) this hypothesis is substantiated. The CAI group ranked item D as the least important use with an average ranked position of 5.86.

Hypothesis 4.

Those students not exposed to CAI will rank as the least important use of CAI item A To take tests.

- Based upon the findings (See Tables 2. and 4., pages 8 and 10) this hypothesis is not substantiated. The non-CAI group ranked item D as the least important use of CAI, with an average ranked position of 6.20. (Item A was ranked fifth at 4.87.)

Hypothesis 5.

Those students exposed to CAI will have a higher percentage of favorable attitudes toward the question, "How do you feel about yourself as a student?" than those students not exposed to CAI.

- Based upon the findings (See Table 5, page 11) this hypothesis is not substantiated.

Hypothesis 6.

Those students exposed to CAI will have a higher percentage of favorable atittudes toward the question, "How do you feel about school?" than those students not exposed to CAI.

- Based upon the findings (See Table 5., page 11) this hypothesis is not substantiated.

Hypothesis 7.

Those students exposed to CAI will have a higher percentage of favorable attitudes toward the question, "How do you feel about mathematics?" than those students not exposed to CAI.

- Based upon the findings (See Table 5., page 11) this hypothesis is substantiated. The CAI group had 60.0% favorable attitudes compared to 57.8% favorable attitudes recorded for the non-CAI group.

Hypothesis 8.

Those students exposed to CAI will have a higher percentage of favorable attitudes toward the question "How do you feel about Computer-Assisted Instruction?" than those students not exposed to CAI.

- Based upon the findings (See table 5., page 11) this hypothesis is substantiated. The CAI group had 61.4% favorable attitudes as compared to 53.0% favorable attitudes recorded for the non-CAI group.

Discussion

"To learn new material" is the most important use of CAI, according to the rankings of the more than 300 senior high school mathematics students surveyed (See Tables 3. and 4., pages 9 and 10 - Total Group). The majority (57.2%) of students surveyed expressed favorable attitudes regarding Computer-Assisted Instruction (See Table 6., page 11). Members of the CAI exposed group indicated more favorable attitudes toward CAI and mathematics. Since fewer favorable attitudes toward mathematics were expressed by the non-CAI group, and because the CAI group's experiences were primarily in the subject area of mathematics, it is possible that there may be a direct transfer of attitudes in these two categories. No similar trends were found between the CAI groups favorable attitudes toward CAI and their attitudes expressed relative to themselves as students, and school.

The CAI exposed students consider item D To Play Games as the least important use of CAI (Hypothesis 3. - substantiated). More extensive examination of Tables 1. and 2. (page 8.) reveals that the mean ranked position within all subgroups (CAI as well as non-CAI individual classes) placed item D To Play Games as the least important use of CAI. No similar conclusion related to the most important use can be drawn.

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APPENDIX

Additional Data

Table 7

ATTITUDES

NON-CAI STUDENTS	How Do You Feel About Yourself as a Student?		
	Favorable	Neutral	Unfavorable
Consumer Math N = 15	48.4%	38.3%	13.3%
Algebra II N = 44	58.0%	31.3%	10.7%
Algebra I N = 23	63.0%	25.0%	12.0%
Trigonometry N = 45	50.0%	27.2%	22.8%
Geometry N = 48	60.4%	25.0%	14.0%
Total N = 175			
Average of Columns	56.0%	29.4%	14.6%

Table 8

ATTITUDES

CAI STUDENTS	How Do You Feel About Yourself as a Student?		
	Favorable	Neutral	Unfavorable
Basic Alg. and Geom. N = 12	58.3%	16.7%	25.0%
Algebra II N = 53	57.5%	28.3%	14.2%
Algebra I N = 15	40.0%	30.0%	30.0%
Trigonometry N = 52	50.5%	24.5%	25.0%
Geometry N = 44	44.9%	41.5%	13.6%
TOTAL N = 176			
Average of Columns	50.2%	28.2%	21.6%

Table 9

ATTITUDES

NON-CAI STUDENTS	How Do You Feel About School?		
	Favorable	Neutral	Unfavorable
Consumer Math N = 15	63.4%	15.8%	20.8%
Algebra II N = 44	63.1%	22.4%	14.5%
Algebra I N = 23	66.8%	10.3%	22.9%
Trigonometry N = 45	55.8%	21.1%	23.1%
Geometry N = 48	64.8%	16.4%	18.8%
TOTAL N = 175			
Average of Columns	62.8%	17.2%	20.0%

Table 10

ATTITUDES

CAI STUDENTS	How Do You Feel About School?		
	Favorable	Neutral	Unfavorable
Basic Alg. and Geom. N = 12	57.3%	16.7%	26.0%
Algebra II N = 53	56.6%	25.9%	17.5%
Algebra I N = 15	62.5%	13.3%	24.2%
Trigonometry N = 52	58.9%	18.0%	23.1%
Geometry N = 44	57.4%	28.7%	13.9%
TOTAL N = 176			
Average of Columns	58.5%	20.5%	21.0%

Table 11

ATTITUDES

NON-CAI STUDENTS — How Do You Feel About Mathematics?

	Favorable	Neutral	Unfavorable
Consumer Math N = 15	56.7%	23.3%	20.0%
Algebra II N = 44	53.4%	20.7%	25.9%
Algebra I N = 23	53.3%	17.9%	28.8%
Trigonometry N = 45	59.4%	15.6%	25.0%
Geometry N = 48	66.1%	15.6%	18.3%
TOTAL N = 175			
Average of Columns	57.8%	18.6%	23.6%

Table 12

ATTITUDES

CAI STUDENTS — How Do You Feel About Mathematics?

	Favorable	Neutral	Unfavorable
Basic Alg. and Geom. N = 12	66.7%	12.5%	20.8%
Algebra II N = 53	54.2%	22.2%	23.6%
Algebra I N = 15	63.3%	20.0%	16.7%
Trigonometry N = 52	62.8%	21.9%	15.3%
Geometry N = 44	53.1%	29.8%	17.1%
TOTAL N = 176			
Average of Columns	60.0%	21.3%	18.7%

Table 13

ATTITUDES

NON-CAI STUDENTS	How Do You Feel About Computer-Assisted Instruction?		
	Favorable	Neutral	Unfavorable
Consumer Math N = 15	49.2%	30.0%	20.8%
Algebra II N = 44	54.3%	37.7%	8.0%
Algebra I N = 23	65.8%	23.9%	10.3%
Trigonometry N = 45	49.2%	33.6%	17.2%
Geometry N = 48	46.4%	38.1%	14.5%
TOTAL N = 175			
Average of Columns	53.0%	32.7%	14.6%

Table 14

ATTITUDES

CAI STUDENTS	How Do You Feel About Computer-Assisted Instruction?		
	Favorable	Neutral	Unfavorable
Basic Alg. and Geom. N = 12	59.4%	24.0%	16.6%
Algebra II N = 53	57.5%	30.7%	11.8%
Algebra I N = 15	73.3%	19.2%	7.5%
Trigonometry N = 52	58.2%	25.0%	16.8%
Geometry N = 44	58.5%	32.1%	9.4%
TOTAL N = 176			
Average of Columns	61.4%	26.2%	12.4%

b) Research Designs for Materials Developed Elsewhere

(1) Physics – Florida State University

The study in physics, planned and conducted by John M. Boblick, during the 1970-71 school year was intended to test the hypothesis that, given the opportunity to take computer generated review quizzes, student achievement on a standardized test would be directly affected. A study of student attitudes was simultaneously conducted.

At Florida State University, the introductory physics course for nonscience majors parallels the PSSC (Physical Science Study Committee) course widely used in the nation's secondary schools. The computer-based version of the FSU course was designed to employ the computer as the manager of the multimedia instructional packages developed for the course.

These instructional packages included taped lectures, PSSC motion pictures, single-concept film loops, and textbook reading assignments. Through the use of on-line CAI quizzes, the student's attainment of the objectives of the instructional packages was evaluated and the assignment of the next instructional package was made. Should the student perform unsatisfactorily on a quiz, his progress through the program was stopped until he reviewed the appropriate instructional package and obtained satisfactory results on the quiz.

A typical sequence of instructional packages, dealing with a given topic or concept, began with a reading assignment in the textbook. The student then took a short quiz which provided him with feedback on his answers, including hints when they were requested or were necessary. Successful completion of this quiz provided the student with his next assignment, usually a taped lecture. An on-line quiz on the audio-taped lecture was followed by the assignment of a film or film loop, which was also followed by a quiz. The sequence was completed by giving the student a reading assignment on the next topic to be studied.

Students enrolled in this version of the course were able to progress through the course at their own pace, using the computer-based quizzes to evaluate their attainment of the objectives of the instructional packages.

The organizational plan of Albert Einstein High School did not lend itself to easy adaptation of the FSU physics program as it was employed on the college level. Secondary schools generally arrange both the pupil's and the teacher's activities during the school day into a much fuller schedule, making it difficult to provide the time and facilities for an individually-paced, multimedia program of the type developed at Florida State. Modification of the program to fit into the existing organization of the school was necessary before it could be employed on the high school level.

Use of the program within MCPS centered around the employment of the quizzes as study-review quizzes, which the student could use to evaluate his attainment of the quiz objectives. Reading assignment quizzes and audio-tape quizzes on the same topic were combined with the student's progress evaluated at the point where the reading quiz normally ended. Here the student is given the O.K. to continue with the quiz or is sent back to the classroom to restudy the lesson before repeating the quiz. An intermediate performance on the quiz gives the student the choice of repeating the quiz or continuing with the program. Film quizzes may be selected individually from the separate file in which they have been placed.

To make the quizzes easily accessible to the student, an index was constructed to coincide with the structure of the PSSC course. After signing on the computer terminal, the student is presented a list of four major parts of the course plus a section on films. Selecting one of these five sections will give the student a list of all quizzes on the topics found within that part of the course. Completion of the quiz returns the student to the master index from which he may select another quiz or sign off.

The index has been designed to permit the student to select a quiz on a topic with which he needs help, whether it is a currently studied topic or one studied earlier in the year which the student wants to review.

Each student was given a list of the quizzes and the corresponding chapter references in his textbook. Using this list, the student was able to determine what quizzes were available for study and could plan to view the quiz when computer time was scheduled. Computer time for the quizzes was scheduled to coincide with the regularly scheduled independent weekly study periods during the year. Students could also choose *not* to use the computer program.

The Dunning-Abeles Physics Text was chosen as the test instrument and was administered in September, 1970, prior to computer use and again in May, 1971. The following table shows the pretest and posttest results for the students at Albert Einstein High School who participated in the study. The national norm is included only for comparison purposes.

Dunning-Abeles Physics Test

Group	Test Date	N	Mean	Raw Score Standard Deviation
Pretest	9/10/70	81	19.4	6.4
Posttest	5/20/71	80	29.2	7.1
National Norm	–	2384	25.5	8.6

Although a detailed analysis was made to determine if a correlation existed between the individual achievement scores and the length of time a student interacted with the computer program or with individual topics within the program, no correlation was found to exist.

The attitude study consisted of students' opinions obtained by their completing an evaluation sheet following each computer session. In addition to rating various aspects of CAI, the student answered questions such as:

> Was this quiz helpful to you?
> What aspect of the quiz did you like best?

The student was also allowed to volunteer any additional comments which he felt were appropriate.

Student reaction to the use of the study-review quizzes, as determined from the completed evaluation forms, was highly positive. This may indicate an enthusiastic endorsement of the Physics P107 program.

(2) Punctuation – McGraw-Hill – University of Texas

In the fall of 1970, arrangements were made with the Educational Developmental Laboratories, Inc., (EDL), a division of the McGraw-Hill Book Company, to conduct a research study of computer-assisted instruction and programmed instruction. Sharon Rose of EDL developed the design, and John Boblick implemented the study at Albert Einstein High School.

The computer-assisted instruction program PUNCT was developed at the University of Texas for the McGraw-Hill Book Company but was essentially an adaptation from the programmed book, *English Review Manual,* written by James A. Gowan.

Following is the research design as conducted at the high school:

Student Sample

Experimental Students

The experimental group of students will consist of those students in four English IV classes and those students in one Advanced Placement English class meeting during the first hour of the day. The Experimental Sample will be further divided into a group using the PUNCT CAI program and a group using the Gowan programmed text.

Control Students

The control group of students will consist of those students in four English IV classes (whose teachers are the same as those teachers in the Experimental English IV classes) meeting during the second hour of the day.

Approximate Size of Groups

Experimental$_1$ (CAI) – 3 classes of approximately 30 students

Experimental$_2$ (Text) – 2 classes of approximately 30 students

Implementation of Design

The classes will spend one day a week on the experimental program.

STEP II Mechanics of Writing – Level 2 will be administered to all students at the outset of the study as a pretest. An alternate form of the same test will be administered as a posttest as each student completes the program. The posttests for the Control students will be administered when half the Experimental students have completed the program and taken the posttest.

The forms to be used are indicated below:

	Pretest	Posttest
E_1* (CAI_1)	A	B
(CAI_2)	B	A
E_2* ($Text_1$)	B	A
($Text_2$)	A	B
E		
Control $_1$*	A	B
2	B	A

*Groups randomly divided into two halves.

In addition, there will be access to the files of the county school district which contain other data, such as ACT scores and IQ scores.

Materials and Service

EDL/McGraw-Hill has agreed to provide the following materials and service:

(a) Copies of Gowen's *English Review Manual* for the E_2 students.

(b) Copies of the STEP test (equal to about one-fourth of the sample) and sufficient answer sheets for all students.

(c) Scoring of the STEP tests and copies of the students' scores for Montgomery County school records.

Design

A factorial design will be used with some variables based on the availability of the data or selected at the option of Montgomery County.

Variables may include: treatment
sex
socioeconomic status
scholastic aptitude
ability in English

The pretest was administered on March 1, 1971, and the posttests during May, 1972. The tests and records were collected and forwarded to the McGraw-Hill Company. Analysis of scores and records is still in process at EDL and no results are available at this time.

3. Future Research

Evaluation of the many aspects of computer-assisted and computer-managed instruction remains the principal objective of the on-going project. Year-long research studies into the effectiveness, efficiency, receptivity, cost, and other aspects are currently underway. In addition, other studies concerning CAI techniques, the individualization process, student control of programs, and transfer of learning will be undertaken. Information pertaining to some of these projected studies are contained in the following paragraphs:

Arithmetic

Sixth-grade students at comparable elementary schools are involved in a year-long study to determine the effect of MCPS developed sequential computer diagnosis, drill and tutorial programs in whole numbers, fractions, and per cents. Experimental students will use the terminals a maximum of one-half hour each week, closely coordinated with their individual needs and with the classroom instructional program.

Students will use only those CAI programs for which they have the prescribed entry levels. Terminal time for students is not in addition to but is part of the regularly allotted arithmetic period. In addition to norm-reference testing, these groups will be tested on a criterion-referenced test developed at the project.

Geometry

Five classes of geometry students at Einstein High School are involved in a year-long study. Sixty-five students in two classes will be involved in the computer-managed instruction mode. An additional 73 students in three classes are receiving instruction in a traditional mode. Results of standardized achievement tests and records which measure efficiency will be analyzed and reported.

Algebra II

A third year-long study involving six Algebra II classes at Einstein High School will attempt to replicate the results of the 1970-71 study reported in the Evaluation section. The original design tested results when CAI programs were used for remediation following teacher instruction. This study will investigate situations where CAI programs are used for initial instruction as well as remediation.

Results from these and other studies will be reported after July 1, 1972.

F. COST ANALYSIS

In view of the fact that Phase I (June, 1968, through June, 1969) was devoted entirely to planning, staff orientation and training, and facility development, the budget for this period has not been included. IBM hardware arrived January 30, 1969, but student use of CAI materials did not begin until July, 1969. Any curriculum development which occurred in Phase I would have represented an initial effort of the authors and would not constitute an accurate description of future software costs.

Total expenses for Phase II (June 27, 1969, through June 30, 1970) and for Phase III (July 1, 1970, through June 30, 1971) are summarized in Table 1. This table breaks down the costs into areas such as salaries, hardware, and supplies. It should be noted that in Phase II, 84 per cent of the project's budget was provided by Title III funds, and in Phase III, 80 per cent of the budget was funded under Title III.

Table 1.
Total Expenses Per Year

Area of Cost	Expense – Phase II June, 1969–June, 1970	Expense – Phase III July, 1970–June, 1971
Professional Salaries (Director, Teacher Specialists)	$109,924.00	$ 81,640.50
Supporting Service Salaries (Systems Manager, Programmers, Computer Operators, Staff Aides, Secretaries)	46,988.00	61,485.00
Supplies	1,600.00	1,902.08
Hardware Rental*	101,184.00	138,840.00
Cable and Cable Installation	12,670.00	–
Travel, Fringe Benefits, Other	20,255.00	23,621.45
Total	$292,621.00	$307,489.03

*See Table 2., for breakdown of hardware costs.

This section was prepared by Susan M. Morgan.

Hardware is the largest single expense for any given year. The computer used is the IBM 1500 Instructional System which was designed for CAI research and development. Its maximum number of student terminals is 32. During Phase II, this project had 13 instructional displays (CRT's) and 2 typewriters; while during Phase III, this number was increased to 24 CRT's and 7 typewriters. The breakdown and total costs of hardware is found in Table 2.

Table 2.
Hardware Costs Per Year

Item	Phase II		Phase III	
	Number	Cost	Number	Cost
Card Punch	1	$ 804.00	1	$ 924.00
Central Processing Unit	1	30,120.00	1	37,560.00
Printer	1	3,120.00	1	3,120.00
Multiplex Control	1	8,136.00	1	8,136.00
Card Read Punch	1	3,084.00	1	3,084.00
Control	1	18,864.00	1	20,436.00
Audio Terminal	1	1,284.00	9	11,556.00
Instructional Display	13	11,700.00	24	21,600.00
Image Projector	1	1,044.00	4	4,176.00
Typewriter	2	2,088.00	7	7,308.00
Disk Storage	2	10,080.00	2	10,080.00
Magnetic Tape Unit Control	1	10,860.00	1	10,860.00
Total		$101,184.00		$138,840.00

Traditionally speaking, computers in education have been expensive. As with most existing computer education projects, the cost per student hour is high. This cost refers to the number of hours students are actually working at the computer terminals rather than the number of hours the computer is simply turned on. Table 3 summarizes the costs per student hour for this project during Phase II and III. The primary reason for the low utilization of the system was the lack of available curriculum.

Table 3.
Cost Per Hour

	Student Hours	Total Cost	Cost Per Hour
Actual – including Curriculum Development 1969-70	1,793.45* hours	$292,621.00	$163.16
Actual – including Curriculum Development 1970-71	4,100.7 hours	$307,489.03	$ 74.98

*Estimate

As has been pointed out in various CAI publications, using a computer system to its fullest extent greatly decreases the cost per hour, especially when the organization does not develop its own curriculum. The demands of such a project would generally require a budget like that shown in Table 4. The hardware cost of $134,928 is based upon 30 CRT's, 5 of which are also equipped with image projectors and audio terminals, and 2 typewriters for proctor messages. The personnel required for such a hypothetical project is a systems manager or director, two part-time proctors or teacher aides, and a computer operator. Salaries based upon MCPS's rate of pay for 1971 are given in Table 4.

Table 4.
Hypothetical System – Maximum Use of the IBM 1500 System Computer with No Curriculum Development

Area of Cost	Cost
Hardware*	$134,928.00
Systems Manager's Salary	15,142.00
Two Proctors (part-time)	5,048.00
Computer Operator (part-time)	4,336.00
12 Per Cent of Salaries for Fringe Benefits	2,943.12
Total	$162,397.12
Cost Per Student Hour Based on 51,300 hours**	$ 3.17

*Based on 1971 prices for all items from Table 2, and with a total of 30 instructional displays, 5 audio terminals, 5 image projectors and 2 typewriters.

**Thirty terminals used 9 hours a day (6 regular and 3 adult education) for 180 days a year (school year), plus 30 terminals used 3 hours a day for 30 days (summer school).

The hardware costs are based upon a specific manufacturer's charge when the system is used exclusively for educational purposes. It should be noted that this price forbids using the leased computer for any administrative duties or for providing computer time to others. However, it may prove less expensive in the future to pay a high rate for hardware and be able to utilize the system 24 hours a day, 14 of which could be noneducational.

Another factor not considered in this hypothetical budget is the cost of curriculum. Some of the available curriculum, at least for the IBM 1500 system, was funded by the National Science Foundation and the U.S. Office of Education and is therefore in the public domain. A limited amount of curriculum could be purchased, but it is primarily drill and practice in arithmetic and English.

Cost of developing curriculum considers the author's time for writing the program, the programmer's time for coding, and the cost of the hardware during coding. Data are summarized in Tables 5, 6, and 7. The author's cost is calculated by an estimation of the percentage of time each author devoted to developing curriculum. In Table 5 the mean times are summarized for students who completed the programs developed at this project. The total cost divided by the total mean completion time for programs is the average cost of developing one hour of curriculum, $1,039.00.

Table 5.
Mean Student Time for Completing Curriculum Developed

Curriculum Area	Time (in Minutes)
Elementary Arithmetic	1,157
Junior High School Science	350
Senior High School Mathematics	1,509
Chemistry	279
Physics	346
Total	3,641

Table 6.
Cost of Curriculum

Area of Cost	Average Cost Per Terminal Per Hour	Total Cost
Programmer's Salary 1969-70	$2.54	$ 2,826.00
Programmer's Salary 1970-71	2.66	7,251.16
Hardware Cost for Programmer's Time 1969-70	2.30	2,558.98
Hardware Cost for Programmer's Time 1970-71	1.71	4,661.46
Cost of Author's Time	–	45,778.62
Total Cost of Curriculum Development	–	$63,076.22

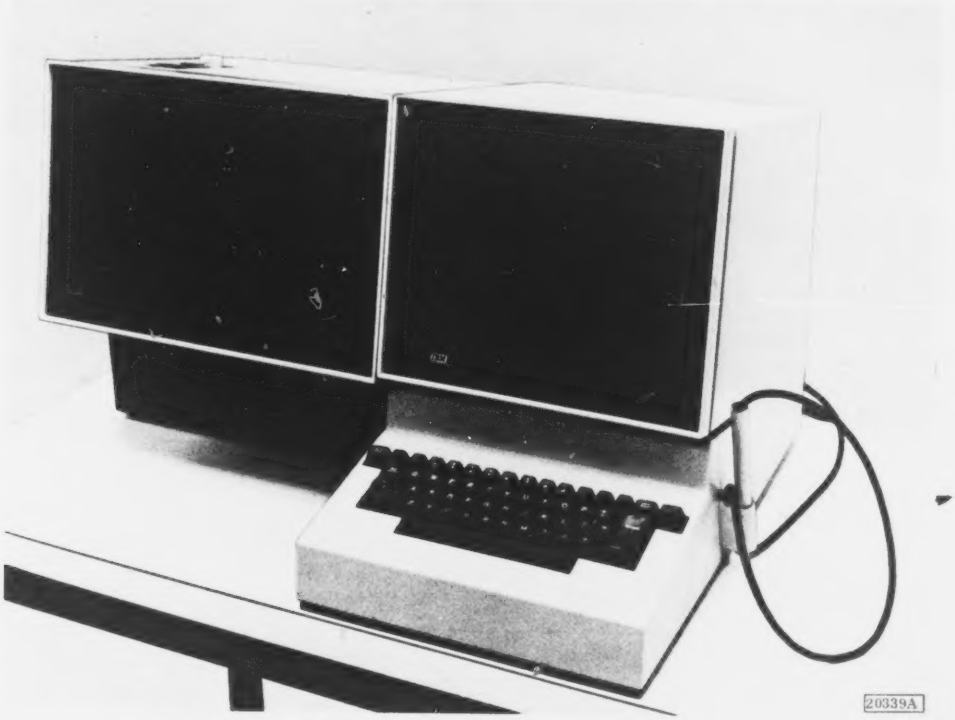
Table 7.

Total Mean Student Time (from Table 5)	60.7 hours
Total Cost of Curriculum Development	$63,076.22
Cost Per Hour	$ 1,039.00

The value of spending this sum on each hour of curriculum is dependent upon the number of students using the particular program. In term, the number of students is dependent upon the size of the project (number of students reached) and the life of the program (number of years program is used). If each hour of curriculum is used by 100 students, the cost per student for an hour on the terminals is $10.39. This cost becomes as low as $0.01 per student per hour if 100,000 students use it. See Table 8.

Table 8.

	100 Students	1,000 Students	10,000 Students	100,000 Students
Cost of Curriculum Per Student Per Hour	$10.39	$1.04	$0.10	$0.01



The Facility and Technical Operations

II. THE FACILITY AND TECHNICAL OPERATIONS

The CAI Project is housed in two schools, Pleasant View Elementary and Albert Einstein High School. Facilities consist of student instructional stations in three locations, a computer terminal room in the elementary school, a mathematics laboratory, and a room adjacent to the instructional materials center in the high school. Project offices and the computer room are also located in the high school. This CAI facility is unique as the elementary school lies 1400 feet east of the high school, necessitating an underground coaxial cable installation between the two schools.

A. SYSTEM

The IBM 1500 Instructional System used in the project is composed of a central control complex, a station control, input-output devices, storage units, and instructional stations.

CENTRAL CONTROL COMPLEX

1131 Central Processing Unit

Arithmetic and control elements for the computer system are contained in the IBM 1131 Central Processing Unit (CPU). Core storage of 32,768 words is housed in the CPU; the unit also contains a magnetic disk cartridge on which can be stored 512,000 two-character words. The core storage cycle time (the time to place a word in core storage or to retrieve it from core storage) is 3.6 microseconds (0.0000036 seconds).

1133 Multiplex Control Enclosure

This device permits the attachment of additional input-output devices and serves as a connecting unit for additional storage units.

STATION CONTROL

1502 Station Control

Time-sharing capabilities are given the system by the 1502 Station Control, which provides an interface between the central control complex and the instructional stations. In the station control are the special features required to control instructional displays, light pens, and random access audio and visual presentations.

INPUT-OUTPUT DEVICES

1442 Model 6 Card Read Punch

Card input/output is provided for the system by this unit capable of reading 300 cards per minute or punching 80 columns per second.

1132 Printer

Printed output, maximum rate of 82 lines per minute (lpm) for alphameric (both letters and numerals) printing and 110 lpm for numeric printing, is provided by the 1132 Printer. All 120 characters which may make up a single line are printed simultaneously.

2415 Magnetic Tape Unit

The 2415 Magnetic Tape provides sequentially accessible storage space for student records, performance data, and other information which does not require random accessibility.

STORAGE DEVICES

2310 Disk Storage

In addition to the storage provided by the CPU, two 2310 Model B2 Disk Storage Units, containing 2 magnetic disk cartridges each, furnish randomly accessible storage space for 2,048,000 words. Although these disk cartridges are interchangeable, providing unlimited storage for course materials, only 5 disks may be on-line at any given time.

STUDENT STATIONS

Student stations, cable connected to the computer and its peripheral equipment, may consist of an instructional display with keyboard and light pen or a typewriter unit. In addition, an image projector and/or audio unit may make up an instructional station.

1510 Instructional Display

An instructional display unit has a cathode ray tube screen, similar in appearance to a television screen, with a typewriter keyboard. It may also have a device called a light pen attached to the side. Letters, numbers, graphics, and combinations of these can be displayed on the screen. As a part of the instruction, students can enter information on the screen by using the typewriter keys. In addition, specific locations on the screen can be identified by pressing the light pen to the screen.

1518 Typewriter

Interaction with the computer may occur at the typewriter unit. A copy of the sequence is then available to the student and the teacher.

1512 Image Projector

The image projector displays black and white or colored images on a rear-view projection screen. These are accessed by the computer whenever a program calls for such a display.

1506 Audio Unit

An audio unit equipped with headphones relates messages to the student upon computer command.

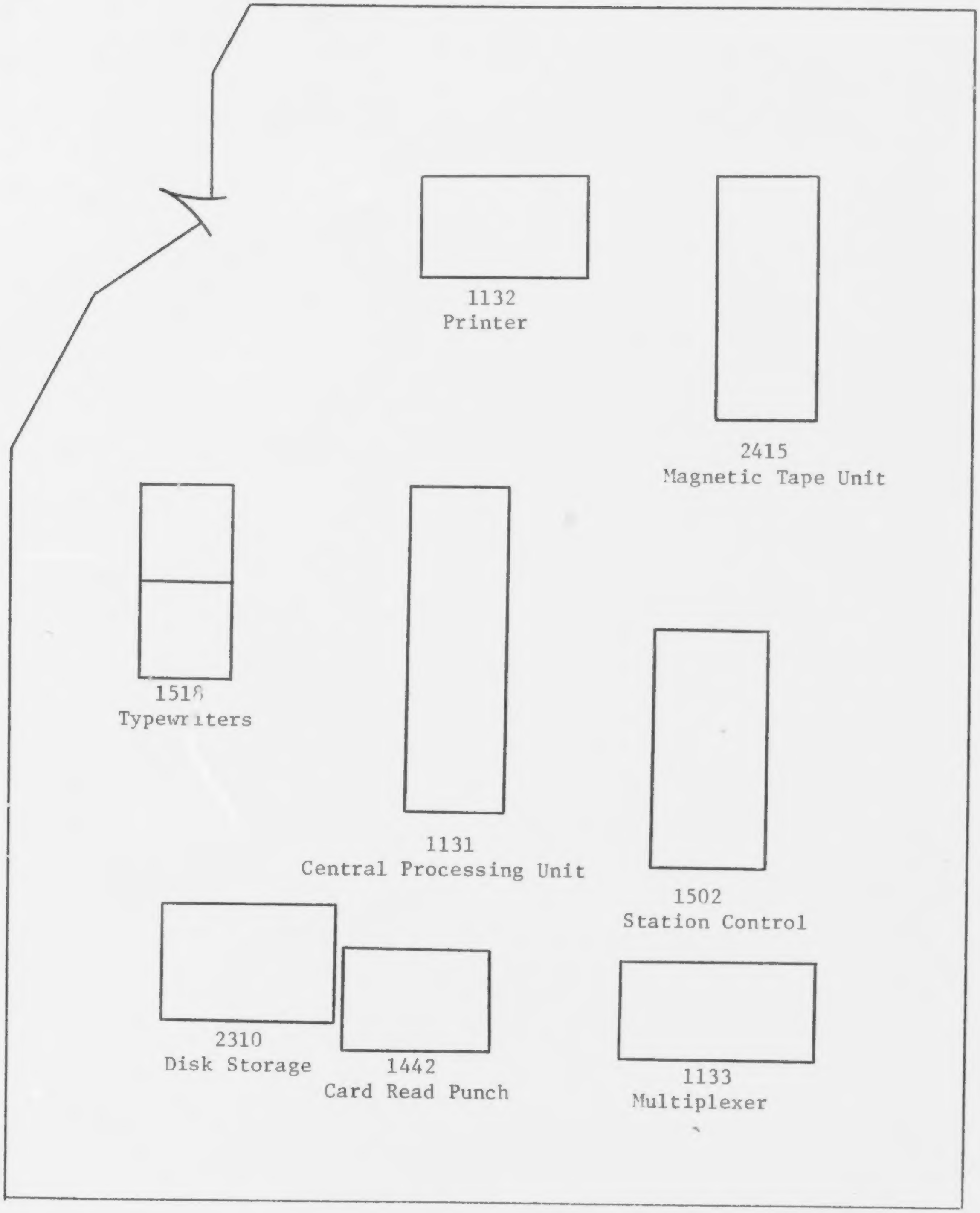
1. Configuration

On the following page is a drawing of the various computer components and their locations to the computer room. For a detailed description of this facility and of the necessary planning, see *Project REFLECT Annual Report, June, 1968, to June, 1969.*

As curriculum was developed, the numbers of components for the instructional stations were increased as shown in the following table.

Location	CRT	Typewriter	Image Projector	Audio Unit
Phase I				
Albert Einstein High School				
Computer Room	1	1	0	0
Math Laboratory	0	1	0	0
Instructional Materials Center	5	0	2	0
Phase II				
Albert Einstein High School				
Computer Room	1	1	0	0
Math Laboratory	4	0	0	0
Instructional Materials Center	4	0	1	0
Pleasant View Elementary School	4	1	0	0
Phase III				
Albert Einstein High School				
Computer Room	1	2	0	0
Math Laboratory	8	4	0	0
Instructional Materials Center	7	1	1	1
Pleasant View Elementary School	8	1	3	8

COMPUTER ROOM


1132
Printer
2415
Magnetic Tape Unit
1518
Typewriters
1131
Central Processing Unit
1502
Station Control
2310
Disk Storage
1442
Card Read Punch
1133
Multiplexer

2. Considerations and Concerns

Vital to the efficient operation of a computer augmented instructional system is the careful consideration of the technical aspects. The impact of demonstrating excellent learning modules can be seriously impaired when excessive response time occurs and when terminal components are inoperative.

The IBM 1500 Instructional System was created for the purposes of research and development in the field of computer-assisted instruction. This hardware has operated in an exceptional manner, and, in the project's experience, there has been little malfunctioning of the equipment resulting in loss of computer time.

Any organization desirous of employing computer technology for educational purposes must be aware of certain necessary facility refinements. Proper temperature and humidity must be provided for the computer system and its peripheral equipment. Thus, air-conditioning is vital to its operation. It should be pointed out that the most down time at the project has been caused by air-conditioning failures.

For both aesthetic and practical reasons, protection for cables and station connectors must be provided. Ideally, the construction of a raised floor in the computer room and in all terminal rooms will prevent accidents to individuals as well as to the equipment. In areas where student terminals are used, an alternative is the construction of conduits on the walls and along the floor areas, or the suspension in troughs from the ceilings. Illustrations of the latter can be seen in the Elementary Subjects Section.

The installation of over 2000 feet of cables connecting Einstein High School to Pleasant View Elementary School, completed in the fall of 1969, was unique for the 1500 system. Several months after its completion, the system suffered interruptions to operations following a severe electrical storm when the underground-overhead coaxial cable acted as a giant antenna. Field engineering services of the IBM Corporation researched the problem and provided various types of lightning suppressors to protect the equipment in the future. Although this trouble continued intermittently over a period of time, it now appears to have been corrected.

On Monday, March 15, 1970, the terminals at the elementary school would not function. Subsequently, the charred remains of a brush fire on the high school football field was discovered. This fire was at the base of a pole upon which rested three sets of cables connecting the two schools. Damage to the cables under the metal conduits was extensive. Although splicing of these cables had not been previously recommended, this repair was successfully completed by the Electric Service Company, the contractors for the original installation. Precautions were taken at this time to secure the cables against possible accidental or malicious damage in the future. It is advisable that technical personnel be aware of the unexpected difficulties which may arise in such a project and make tentative plans to handle these emergencies when they do occur.

Visitors to institutions which demonstrate innovative approaches to learning will be numerous. A successful demonstration should have been planned and rehearsed carefully so nothing is left to chance. Checks should be made to determine that the equipment will function in the way it was intended. Only curriculum which is interesting, valid, and completely debugged should be demonstrated.

B. SUPPORT SOFTWARE

This secion describes a variety of programs which transfer information from the computer into a format which can be used by administrators, teachers, authors, and programmers.

1. Validation Programs

Authors were interested in determining the validity of instructional packages. They wished to examine carefully both the individual and group performances on each objective so that necessary revisions could be made in the objectives, the sequencing, and the presentation of any segment of the module. Print-outs of unidentified answers to questions were of particular value in these revisions.

Ronald Welker, systems manager, and James Eshleman, programmer, developed the following programs to meet the above needs:

> VALID is a two-part validation program written in assembly language. The first part consists of the following information grouped by question: (1) the number of students who tried to answer the question as compared with the number of students who were presented the question; (2) the number of correct answers compared with the number of answers; (3) the number of correct answers compared with the number of students who were presented the question; (4) the discrimination index for the question; and (5) the maximum, minimum, mean, and standard deviation for latency time (the length of time a student takes to answer).
>
> The second part of the program consists of totals for the number of pretest, posttest, diagnostic, and instructional questions tried and information similar to (5) above regarding total time through the MIP.

MCSPL1, an assembly language program, lists performance and latency time information for a given student on a given question or group of questions.

PROGA, a FORTRAN program, prints percentages of correct answers for key questions as well as total time for the module.

PROGB, in FORTRAN, uses a sorted master performance tape to give a listing of all question identifiers followed by a list of the corresponding right, wrong, and unidentified percentages. All unidentified answers and comments are listed as well as the student's number who made the response. Totals for number of students, number of times each question was presented, and number of responses are given for each question.

PROGE, a FORTRAN program, was written to grade the Algebra II final examinations given by CAI, printing the number correct for each student and a tally showing the number of students receiving each score.

PROGX, in FORTRAN, is the same as PROGB except that it uses an unsorted daily performance tape and thus is much slower in the collection of the data.

In addition, a series of statistical programs for research purposes written in A PROGRAMMING LANGUAGE were developed by Susan M. Morgan. The designs and the listings for these programs are contained on the following pages from a booklet written by the developer.

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IV Listings of Programs

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I Introduction - Purpose

This document describes a series of statistical programs stored and available on the IBM 1500 Instructional System. These programs are written in APL (A PROGRAMMING LANGUAGE).

This initial effort is made to aid curriculum writers who are involved in evaluation studies to obtain information as to the effectiveness of CAI modules through the use of either norm-referenced standardized tests or criterion-referenced tests. When new research designs are planned which require other statistical analyses, new APL programs will be developed and those descriptions will be added to this manual.

II Overview

A. Outline of Design

B. List of Assumptions and requirements for tests in design

C. Workspace and program name, free vectors to load scores

D. Program printout with a reference to literature where the formulas were checked.

III Designs

A. Design One
   1. Outline
      a. Group 1 - Experimental
         1) set 1 - pretest scores
         2) set 2 - posttest scores
      b. Group 2 - Control
         1) set 1 - pretest scores
         2) set 2 - posttest scores
   2. Assumptions (from Siegel, pp. 19-20)[1]
      a. The observations must be independent. That is, selection of any one case from the population for inclusion in the sample must not bias the chances of any other case for inclusion, and the score which is assigned to any case must not bias the score which is assigned to any other case.
      b. The observations must be drawn from normally distributed populations.
      c. These populations must have the same variance.
      d. The variables involved must have been measured in at least an interval scale so that it is possible to use the operations of arithmetic on the scores.
   3. Workspace
      a.)load 555001
)copy 555001
      b. Program: S
      c. Scores may be loaded into any vectors A through L.
      d. Groups do not need equal N's.
   4. Printout
      a. Means and standard deviations for each set of scores (checked Spiegel, p. 76.)[2]
      b. Gain scores with their means and standard deviations for each group.
      c. T-score comparing pretest scores with posttest scores for each group (checked Smith, p. 71.)[3]

---

[1] Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill Book Company, 1956), pp. 19-20. Used with permission of McGraw-Hill Book Company.

[2] Murry R. Spiegel, Statistics (New York: Schaum Publishing Company, 1961), p. 76.

[3] G. Milton Smith, A Simplified Guide to Statistics for Psychology and Education (New York: Holt, Rinehart and Winston, Inc., 1962), p. 71.

d. T-score comparing experimental pretest with control pretest (checked Dixon and Massey, p. 117.)[1]
e. T-score comparing gain scores for experimental group with gain scores for control group (checked Dixon and Massey, p. 117.)[2]

B. Design Two
1. Outline
a. Group 1 - Experimental
1) subgroup 1 - B1 (can be any fixed subdivision, i.e., ability groups)
a) set 1 - pretest scores
b) set 2 - posttest scores
2) subgroup 2 - B2
a) set 1 - pretest scores
b) set 2 - posttest scores
b. Group 2 - Control
1) subgroup 1 - B1
a) set 1 - pretest scores
b) set 2 - posttest scores
2) subgroup 2 - B2
a) set 1 - pretest scores
b) set 2 - posttest scores
2. Assumptions
a. All assumptions from design one
b. The means of these populations must be linear combinations of effects due to columns and/or rows. That is, the effects must be additive.
3. Workspace
a.)load 555002
)copy 555002
b. Program: S
c. Scores may be loaded into any vectors A through L.
d. Neither groups nor subgroups require equal N's.
4. Printout
a. Means and standard deviations for all sets of scores
b. Gain scores with their means and standard deviations for each subgroup
c. Analysis of variance data on the gain scores (checked Lordahl, p. 155.)[3]

C. Design 2A
1. Outline
a. A1 - a group (experimental or control) or an ability level (high or low)
1) B1 (group or level)
a) set 1 - pretest scores
b) set 2 - posttest scores
2) B2
a) set 1 - pretest scores
b) set 2 - posttest scores

---

[1] Wilfred J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, Inc., 1969), p. 117.

[2] Ibid.

[3] Daniel S. Lordahl, Modern Statistics for Behavioral Science (New York: The Ronald Press Company, 1967), p. 155.

- b. A2
  - 1) B1
    - a) set 1 - pretest scores
    - b) set 2 - posttest scores
  - 2) B2
    - a) set 1 - pretest scores
    - b) set 2 - posttest scores
- 2. Assumptions - same as Design Two
- 3. Workspace
  - a.)load 555012
)copy 555012
  - b. Program: S
  - c. Scores may be loaded into any vectors A through L.
  - d. There must be equal N's in groups and subgroups.
- 4. Printout - 3-way analysis of variance data

- D. Design Three
  - 1. Outline
    - a. A1 - a group, subgroup or any fixed variable
      - 1) B1 - a group, subgroup or any fixed variable
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
      - 2) B2
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
      - 3) B3
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
    - b. A2
      - 1) B1
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
      - 2) B2
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
      - 3) B3
        - a) set 1 - pretest scores
        - b) set 2 - posttest scores
  - 2. Assumptions - same as Design Two
  - 3. Workspace
    - a.)load 555003
)copy 555003
    - b. Program: S
    - c. Scores may be loaded into any vectors A through L.
    - d. Neither groups nor subgroups require equal N's.
  - 4. Printout
    - a. Means and standard deviations for each set of scores
    - b. Gain scores with means and standard deviations for each subgroup

        c. Analysis of variance data (checked Lordahl, p. 158,[1] and Winer, p. 233.)[2]
        d. Neither groups nor subgroups require equal N's.
    E. Design 3A
        1. Outline - same as Design Three
        2. Assumptions - same as Design Two
        3. Workspace
            a.)load 555013
)copy 555013
            b. Program: S
            c. Scores may be loaded into any vectors A through L.
            d. There must be equal N's in groups and subgroups.
        4. Printout - 3-way analysis of variance data (checked Winer, p. 255.)[3]

IV Listings of Programs

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[1] Lordahl, *op. cit*., p. 158.

[2] B. J. Winer, *Statistical Principles in Experimental Design* (New York: McGraw-Hill Book Company, Inc., 1962), p. 233 .

[3] *Ibid*., p. 255.

```
  ∇S[⎕]∇
∇S;A;B;C;D;A̲;B̲
[1]   'DESIGN 1'
[2]   'EXP-PRE'
[3]   A←⎕
[4]   'M  = ';M A
[5]   'SD = ';S̲ A
[6]   'POST'
[7]   B←⎕
[8]   'M  = ';M B
[9]   'SD = ';S̲ B
[10]   ''
[11]   'GAIN SCORES'
[12]   A̲←A Z B
[13]   'M  = ';M A̲
[14]   'SD = ';S̲ A̲
[15]   ''
[16]   'T COMP PRE TO POST GAIN-EXP'
[17]   'T  = ';A T B
[18]   'DF = ';(ρA)-1
[19]   ''
[20]   'CONT-PRE'
[21]   C←⎕
[22]   'M  = ';M C
[23]   'SD = ';S̲ C
[24]   'POST'
[25]   D←⎕
[26]   'M  = ';M D
[27]   'SD = ';S̲ D
[28]   ''
[29]   'GAIN SCORES'
[30]   B̲←C Z D
[31]   'M  = ';M B̲
[32]   'SD = ';S̲ B̲
[33]   ''
[34]   'T COMP PRE TO POST GAIN-CONT'
[35]   'T  = ';C T D
[36]   'DF = ';(ρC)-1
[37]   ''
[38]   'T COMP EXP PRE TO CONT PRE'
[39]   'T  = ';A T̲ C
[40]   'DF = ';(ρA)+(ρC)-2
[41]   ''
[42]   'T COMP EXP GAIN TO CONT GAIN'
[43]   'T  = ';A̲ T̲ B̲
[44]   'DF = ';(ρA̲)+(ρB̲)-2
  ∇
```

```
   )FNS
← M∘  ←∘R∘    S    ←∘T∘  ←∘U∘  ←∘W∘  ←∘Z∘  ← Q̲∘  ← S̲∘  ←∘T̲∘

  ∇M[⎕]∇
∇N←M X
[1]  N←+/X÷ρX
 ∇


  ∇R[⎕]∇
∇R̲←X R Y
[1]  R̲←(X W Y)×((1÷ρX)+(1÷ρY))*.5
 ∇


  ∇T[⎕]∇
∇O←Y T Y̲
[1]  O←(M (Y Z Y̲))÷((Y U Y̲)÷(((ρY)-1)*.5))
 ∇


  ∇U[⎕]∇
∇Q←X U X̲
[1]  Q←((+/((X Z X̲)*2)÷ρX)-((M (X Z X̲))*2))*.5
 ∇


  ∇W[⎕]∇
∇P̲←X W Y
[1]  P̲←(((Q̲ X)+(Q̲ Y))÷((ρX)+(ρY)-(2)))*.5
 ∇

  ∇Z[⎕]∇
∇P←W Z W̲
[1]  P←W̲-W
 ∇

  ∇Q̲[⎕]∇
∇Q←Q̲ X
[1]  Q←(+/(X*2))-(((+/X)*2)÷ρX)
 ∇


  ∇S̲[⎕]∇
∇N̲←S̲ X
[1]  N̲←((+/((X-(M X))*2))÷ρX)*.5
 ∇

  ∇T̲[⎕]∇
∇Q̲←V T̲ V̲
[1]  Q̲←((M V)-(M V̲))÷(V R V̲)
 ∇
```

```
  ∇S[⎕]∇
∇S;A;B;C;D;E;F;A̲;B̲;C̲;D̲;G̲;H̲;I̲
[1]  'DESIGN 2'
[2]  I←9
[3]  'EXP-B1'
[4]  I←I+4
[5]  'PRE'
[6]  A←⎕
[7]  M A
[8]  'POST'
[9]  B←⎕
[10]  M B
[11]  A T B
[12]  →I
[13]  A̲←A T̲ B
[14]  M A̲
[15]  'EXP-B2'
[16]  →4
[17]  B̲←A T̲ B
[18]  M B̲
[19]  'CONT-B1'
[20]  →4
[21]  C̲←A T̲ B
[22]  M C̲
[23]  'CONT-B2'
[24]  →4
[25]  D̲←A T̲ B
[26]  M D̲
[27]  A←M̲ A̲
[28]  B←M̲ B̲
[29]  C←M̲ C̲
[30]  D←M̲ D̲
[31]  Z←4÷((A̲ U B̲)+(C̲ U D̲))
[32]  Z̲←((A U̲ B)+(C U̲ D))÷2
[33]  Y←((A+B+C+D)*2)÷4
[34]  Y̲←((A U̲ C)+(B U̲ D))÷2
[35]  V←(A*2)+(B*2)+(C*2)+(D*2)
[36]  V̲←(R̲ A̲)+(R̲ B̲)+(R̲ C̲)+(R̲ D̲)
[37]  W←(ρA̲)+(ρB̲)+(ρC̲)+(ρD̲)-(4)
[38]  W̲←V̲÷W
[39]  G̲←Z×(Z̲-Y)
[40]  H̲←Z×(Y̲-Y)
[41]  I̲←Z×(((V-Z̲)-Y̲)+Y)
[42]  'SOURCE      SS       DF       MS       F'
[43]  '---------------------------------------------'
[44]  'A GROUPS   ';G̲;'     1      ';G̲;'    ';G̲÷W̲
[45]  'B          ';H̲;'     1      ';H̲;'    ';H̲÷W̲
[46]  'AB         ';I̲;'     1      ';I̲;'    ';I̲÷W̲
[47]  '/IN CELL   ';V̲;'   ';W;'   ';W̲
 ∇
```

```
    )FNS
← M∘   ← M̲∘     S    ←∘T∘   ←∘U∘   ← R̲∘   ←∘T̲∘   ←∘U̲∘

    ∇M[⎕]∇
  ∇N←M X
  [1]   Q←+/X÷ρX
  [2]   S̲←(+/((X-Q)*2)÷ρX)*.5
  [3]   'M  = ';Q
  [4]   'SD = ';S̲
  [5]   N←0
   ∇

    ∇M̲[⎕]∇
  ∇P←M̲ X
  [1]   P←+/X÷ρX
   ∇

    ∇T[⎕]∇
  ∇N̲←X T Y
  [1]   'GAIN SCORES'
  [2]   N̲←Y-X
   ∇

    ∇U[⎕]∇
  ∇Q̲←X U Y
  [1]   Q̲←(1÷ρX)+(1÷ρY)
   ∇

    ∇R̲[⎕]∇
  ∇R←R̲ X
  [1]   R←(+/(X*2))-(((+/X)*2)÷ρX)
   ∇

    ∇T̲[⎕]∇
  ∇O←X T̲ Y
  [1]   O←Y-X
   ∇

    ∇U̲[⎕]∇
  ∇P̲←X U̲ Y
  [1]   P̲←(X+Y)*2
   ∇
  ∇S[⎕]∇
∇S;A;B;C;D;E;F;G;H
[1]  '2A'
[2]  Z←0
[3]  Z̲←0
[4]  V←0
[5]  M←11
[6]  'A1-B1-C1'
[7]  M←M+3
[8]  M̲←⎕
[9]  R←ρM̲
[10]  Z←Z+(+/(M̲*2))
[11]  Z̲←Z̲+(+/M̲)
[12]  V←V+((+/M̲)*2)
[13]  →M
[14]  A←S̲ M̲
[15]  'A1-B1-C2'
[16]  →7
[17]  B←S̲ M̲
[18]  'A1-B2-C1'
[19]  →7
[20]  C←S̲ M̲
[21]  'A1-B2-C2'
[22]  →7
[23]  D←S̲ M̲
[24]  'A2-B1-C1'
[25]  →7
[26]  E←S̲ M̲
[27]  'A2-B1-C2'
[28]  →7
[29]  F←S̲ M̲
[30]  'A2-B2-C1'
[31]  →7
[32]  G←S̲ M̲
[33]  'A2-B2-C2'
[34]  →7
[35]  H←S̲ M̲
[36]  R̲←(4×R)
[37]  Z̲←(Z̲*2)÷(8×R)
[38]  Y←(((A+B+C+D)*2)+((E+F+G+H)*2))÷R̲
[39]  Y̲←(((A+B+E+F)*2)+((C+D+G+H)*2))÷R̲
[40]  X←(((A+E+C+G)*2)+(B+F+D+H)*2)÷R̲
[41]  X̲←((A N̲ B)+(C N̲ D)+(E N̲ F)+(G N̲ H))÷(2×R)
[42]  W←((A N̲ C)+(B N̲ D)+(E N̲ G)+(F N̲ H))÷(2×R)
[43]  W̲←((A N̲ E)+(C N̲ G)+(B N̲ F)+(D N̲ H))÷(2×R)
[44]  V←V÷R
[45]  A̲←Y-Z̲
[46]  B̲←Y̲-Z̲
[47]  C̲←X-Z̲
[48]  D̲←((X̲-Y)-Y̲)+Z̲
```

```
[49]  E←((W-Y)-X)+Z
[50]  F←((W-Y)-X)+Z
[51]  G←((((((V-X)-W)-W)+Y)+Y)+X)-Z
[52]  H←Z-V
[53]  I←Z-Z
[54]  J←H÷(8×(R-1))
[55]  'SOURCE         SS         DF         MS          F'
[56]  'A           ';A;'     1      ';A;'      ';A÷J
[57]  'B           ';B;'     1      ';B;'      ';B÷J
[58]  'C           ';C;'     1      ';C;'      ',C÷J
[59]  'AB          ';D;'      1      ';D;'      ';D÷J
[60]  'AC          ';E;'      1      ';E;'      ';E÷J
[61]  'BC          ';F;'      1      ';F;'      ';F÷J
[62]  'ABC         ';G;'      1      ';G;'      ';G÷J
[63]  'W.IN CELL   ';H;'    ';8×(R-1);' ';J
[64]  'TOTAL      ';I;'    ';7+(8×(R-1))
 ∇




   )FNS
←∘N∘     S    ← S∘


  ∇N[⎕]∇
∇P←X  N  Y
[1]  P←(X+Y)*2
 ∇


  ∇S[⎕]∇
∇Q←S  X
[1]  Q←+/X
 ∇
```

```
  ∇S[⎕]∇
∇S;A;B;C;D;E;F;G;H;I;J;K;L;A̲;B̲;C̲;D̲;E̲;F̲;G̲;H̲;I̲;J̲;K̲;L̲
[1]   'DESIGN 3'
[2]   I←9
[3]   'A1-B1'
[4]   I←I+4
[5]   'PRE'
[6]   A←⎕
[7]   M A
[8]   'POST'
[9]   B←⎕
[10]   M B
[11]   A T B
[12]   →I
[13]   A̲←A T̲ B
[14]   M A̲
[15]   'A1-B2'
[16]   →4
[17]   B̲←A T̲ B
[18]   M B̲
[19]   'A1-B3'
[20]   →4
[21]   C̲←A T̲ B
[22]   M C̲
[23]   'A2-B1'
[24]   →4
[25]   D̲←A T̲ B
[26]   M D̲
[27]   'A2-B2'
[28]   →4
[29]   E̲←A T̲ B
[30]   M E̲
[31]   'A2-B3'
[32]   →4
[33]   F̲←A T̲ B
[34]   M F̲
[35]   A←M̲ A̲
[36]   B←M̲ B̲
[37]   C←M̲ C̲
[38]   D←M̲ D̲
[39]   E←M̲ E̲
[40]   F←M̲ F̲
[41]   Z←6÷((A̲ U B̲)+(C̲ U D̲)+(E̲ U F̲))
[42]   Z̲←(((A+B+C)*2)+((D+E+F)*2))÷3
[43]   Y←((A+B+C+D+E+F)*2)÷6
[44]   Y̲←((A U̲ D)+(B U̲ E)+(C U̲ F))÷2
[45]   V←(A*2)+(B*2)+(C*2)+(D*2)+(E*2)+(F*2)
[46]   V̲←(R̲ A̲)+(R̲ B̲)+(R̲ C̲)+(R̲ D̲)+(R̲ E̲)+(R̲ F̲)
[47]   W←(ρA̲)+(ρB̲)+(ρC̲)+(ρD̲)+(ρE̲)+(ρF̲)-(6)
```

```
[48]  W̲←V̲÷W
[49]  G̲←Z×(Z̲-Y)
[50]  H̲←Z×(Y̲-Y)
[51]  I̲←Z×(((V-Z̲)-Y̲)+Y)
[52]  'SOURCE        SS          DF          MS          F'
[53]  '-------------------------------------------------'
[54]  'A            ';G̲;'      1         ';G̲;'      ';G̲÷W̲
[55]  'B            ';H̲;'      2         ';H̲;'       ';H̲÷W̲
[56]  'AB           ';I̲;'      2         ';I̲;'      ';I̲÷W̲
[57]  '/IN CELL     ';V̲;'     ';W;'   ';W̲
 ∇


   )FNS
← M∘   ← M̲∘     S    ←∘T∘   ←∘U∘   ← R̲∘   ←∘T̲∘   ←∘U̲∘


   ∇M[⎕]∇
∇N←M X
[1]   Q←+/X÷ρX
[2]   S̲←(+/((X-Q)*2)÷ρX)*.5
[3]   'M  = ';Q
[4]   'SD = ';S̲
[5]   N←0
 ∇


   ∇M̲[⎕]∇
∇P←M̲ X
[1]   P←+/X÷ρX
 ∇


   ∇T[⎕]∇
∇N̲←X T Y
[1]   'GAIN SCORES'
[2]   N̲←Y-X
 ∇


   ∇U[⎕]∇
∇Q̲←X U Y
[1]   Q̲←(1÷(ρX))+(1÷(ρY))
 ∇


   ∇R̲[⎕]∇
∇R←R̲ X
[1]   R←(+/(X*2))-(((+/X)*2)÷ρX)
 ∇
```

```
  ∇T[⎕]∇
∇O←X T Y
[1]  O←Y-X
 ∇
```

```
  ∇U[⎕]∇
∇P←X U Y
[1]  P←(X+Y)*2
 ∇
```

CORRECTION - Page 488

```
[52]  'SOURCE          SS          DF          MS          F'
[53]  '-----------------------------------------------------'
[54]  'A          ';G;'          1          ';G;'          ';G÷U
[55]  'B          ';H;'          2          ';H÷2;'          ';(H÷2)÷U
[56]  'AB          ';I;'          2          ';I÷2;'          ';(I÷2)÷U
[57]  '/IN CELL   ';V;'          ';W;'          ';U
 ∇
```

```
      ∇S[⎕]∇
    ∇S;A;B;C;D;E;F;G;H;I;J;K;L
[1]   '3A'
[2]   Z←0
[3]   Z̲←0
[4]   V←0
[5]   M←11
[6]   'A1-B1-PRE'
[7]   M←M+3
[8]   M̲←⎕
[9]   R←(⍴M̲)
[10]   Z←Z+(+/(M̲*2))
[11]   Z̲←Z̲+(+/M̲)
[12]   V←V+((+/M̲)*2)
[13]   →M
[14]   A←T M̲
[15]   'POST'
[16]   →7
[17]   B←T M̲
[18]   'A1-B2-PRE'
[19]   →7
[20]   C←T M̲
[21]   'POST'
[22]   →7
[23]   D←T M̲
[24]   'A1-B3-PRE'
[25]   →7
[26]   E←T M̲
[27]   'POST'
[28]   →7
[29]   F←T M̲
[30]   'A2-B1-PRE'
[31]   →7
[32]   G←T M̲
[33]   'POST'
[34]   →7
[35]   H←T M̲
[36]   'A2-B2-PRE'
[37]   →7
[38]   I←T M̲
[39]   'POST'
[40]   →7
[41]   J←T M̲
[42]   'A2-B3-PRE'
[43]   →7
[44]   K←T M̲
[45]   'POST'
[46]   →7
[47]   L←T M̲
```

```
[48]  Z̲←(Z̲*2)÷(12×R)
[49]  Y←(((A+B+C+D+E+F)*2)+((G+H+I+J+K+L)*2))÷(6×R)
[50]  Y̲←(((A+B+G+H)*2)+((C+D+I+J)*2)+((E+F+K+L)*2))÷(4×R)
[51]  X←(((A+G+C+I+E+K)*2)+((B+H+D+J+F+L)*2))÷(6×R)
[52]  X̲←((A N̲ B)+(C N̲ D)+(E N̲ F)+(G N̲ H)+(I N̲ J)+(K N̲ L))÷(2×R)
[53]  W←(((A+C+E)*2)+((B+D+F)*2)+((G+I+K)*2)+((H+J+L)*2))÷(3×R)
[54]  W̲←((A N̲ G)+(C N̲ I)+(E N̲ K)+(B N̲ H)+(D N̲ J)+(F N̲ L))÷(2×R)
[55]  V←V÷R
[56]  A̲←Y-Z̲
[57]  B̲←Y̲-Z̲
[58]  C̲←X-Z̲
[59]  D̲←(((X̲-Y)-Y̲)+Z̲)
[60]  E̲←(((W-Y)-X)+Z̲)
[61]  F̲←(((W̲-Y̲)-X)+Z̲)
[62]  G̲←(((((((V-X̲)-W)-W̲)+Y)+Y̲)+X)-Z̲)
[63]  H̲←Z-V
[64]  I̲←Z-Z̲
[65]  J̲←H̲÷(12×(R-1))
[66]  'SOURCE        SS          DF          MS          F'
[67]  '--------------------------------------------------',
[68]  'A           ';A̲;'  1      ';A̲;' ';A̲÷J̲
[69]  'B           ';B̲;'  2      ';B̲÷2;' ';(B̲÷2)÷J̲
[70]  'C           ';C̲;'  1      ';C̲;' ';C̲÷J̲
[71]  'AB          ';D̲;'  2      ';D̲÷2;' ';(D̲÷2)÷J̲
[72]  'AC          ';E̲;'  1      ';E̲;' ';E̲÷J̲
[73]  'BC          ';F̲;'  2      ';F̲÷2;' ';(F̲÷2)÷J̲
[74]  'ABC         ';G̲;'  2      ';G̲÷2;' ';(G̲÷2)÷J̲
[75]  'W/IN CELL ';H̲;' ';12×(R-1);' ';J̲
[76]  'TOTAL       ';I̲;' ';11+(12×(R-1))
 ∇


   )FNS
←∘N̲∘     S    ← T∘   ←∘S̲∘


  ∇N̲[⎕]∇
∇P̲←X N̲ Y
[1]  P̲←(X+Y)*2
 ∇


  ∇T[⎕]∇
∇Q←T X
[1]  Q←+/X
 ∇


  ∇S̲[⎕]∇
∇Q̲←Y S̲ X
[1]  Q̲←(+/X)+(+/Y)
 ∇
```

2. Financial Accounting

An accounting program was developed so that the director would have detailed and summarized information concerning project finances. The data provided him with input for monitoring and decision-making. In addition, it made reconciliation with the records from the Department of Financial Services a simpler chore.

The programs described below were written by Mary C. Eshleman and James Eshleman.

ACCT and PAYRL, FORTRAN programs, provided management with information on allocations, disbursements, encumbrances, and unencumbered balances for the accounts used in FY '70 by the CAI Project.

ACC71, a FORTRAN program, replaced the ACCT and PAYRL programs and provided management with a more concise report showing allocations, transfers, disbursements, encumbrances, and unencumbered balances for all accounts used by the CAI Project in FY '71.

3. Other Programs

A need for additional programs occurred at various times, and if available from other installations, they were secured. If no program was known to exist, it was developed at the project. The descriptions of the programs developed at the project by Ronald Welker and James Eshleman, or acquired from the institution named, follow:

PROGC, a FORTRAN program, provides management with a summary sheet showing computer usage for a month. It gives detailed information on the number of students on each course, how often they signed on during the month, and their total and mean times on the terminals.

PROGD, another FORTRAN program, gives time information similar to PROGC except that this program gives the information for only a selected group of students.

REGIS, an assembly language program, is a background program which registers student numbers using card input. Prior to the implementation of this program, it was necessary to manually register each number using either a typewriter or CRT terminal.

DELET, an assembly language program, is a companion to REGIS. It deletes student numbers using card input.

PTUR, a FORTRAN program, generates a report showing the total number of hours spent programming and debugging a single modular instructional package.

SRTMG, in assembly language, is a sort-merge program written at Pennsylvania State University and modified for the MCPS system. It now provides two sorting formats and is used monthly to sort performance data into acceptable input for various other programs.

SLCPY, an assembly language program, written at the United States Naval Academy, allows for selectively copying student performance records for specified students from our master tapes.

TPDSK, written in assembly language, is a tape-to-disk program which was written at Stanfrod University. It is used to provide tape back-up of course material stored on disk.

RAS, in assembly language, was written at Stanford University and is used frequently to reassemble a course. This causes the course to execute faster and occupy less disk space.

III. STAFF DEVELOPMENT

Since July, 1969, staff development activities have focused on informing educators and others about the uses of the computer in the instructional process and conducting courses for teachers who will use and develop CAI and CMI curricula.

Based upon the experiences gained during the first year of the project's operation, it was decided to offer a program to twelve-month teachers interested in developing curriculum modules. This workshop, instituted on a voluntary basis for those teachers, would teach the writing of modular instructional packages, utilizing the principles of instructional technology. Twenty-three teachers and one principal met daily in a six-week half-day course led by Kenneth A. Walter.

The supporting teacher program which was begun during this first year of the project was continued the following school year. Selected teachers who had participated in the original courses came to the project one day every two weeks to develop, revise, and evaluate CAI and CMI modular instructional packages. In addition, two members of the summer course joined the supporting teachers, one joining the elementary design team and the other replacing a mathematics teacher who had been promoted within the school system.

Since that time, replacements on the design teams have all had backgrounds in educational technology, particularly in the areas of writing behavioral objectives and criterion test items. This training was acquired from inservice workshops or college courses.

In July, 1970, Mr. Walter, who had planned and conducted most of the staff development activities, was appointed an intern in the administrative staff of a county high school. This vacancy was not filled, so other staff members assumed the responsibilities of this essential project activity.

In January, 1971, a teacher specialist was appointed the acting director of the project, and a teacher from the mathematics design team was selected as the replacement. The smooth transition between these two positions emphasized the success of the supporting teacher program, which can serve as a reservoir of trained individuals, replacing, or increasing the existing staff when necessary.

A. TRAINING MANUAL

A direct result of the supporting teacher training program was the writing of *Authoring Individualized Learning Modules: A Teacher Training Manual* by Kenneth A. Walter. This document provides instructors of courses for curriculum developers and classroom teachers with a ready source of useable sequential materials on instructional technology. Sample pages from this document and a copy of the order blank appear on the following pages.

PROJECT REFLECT
COMPUTER-ASSISTED INSTRUCTION PROJECT
TITLE III, E.S.E.A OF 1965

AUTHORING INDIVIDUALIZED LEARNING MODULES:
A Teacher Training Manual

MONTGOMERY COUNTY PUBLIC SCHOOLS
Rockville, Maryland
Homer O. Elseroad, Superintendent

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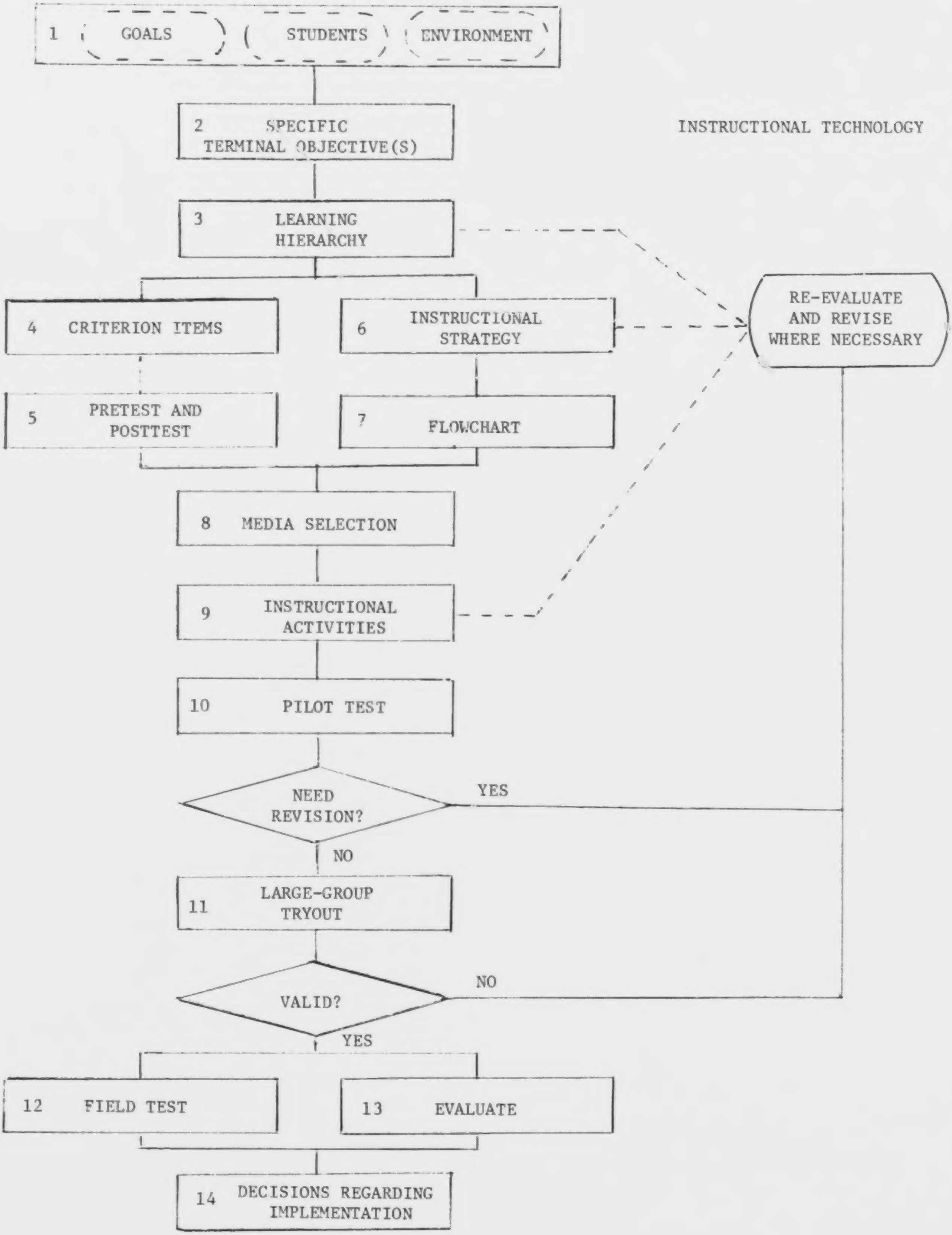
1 GOALS
STUDENTS
ENVIRONMENT
2 SPECIFIC TERMINAL OBJECTIVE(S)
INSTRUCTIONAL TECHNOLOGY
3 LEARNING HIERARCHY
RE-EVALUATE AND REVISE WHERE NECESSARY
4 CRITERION ITEMS
6 INSTRUCTIONAL STRATEGY
5 PRETEST AND POSTTEST
7 FLOWCHART
8 MEDIA SELECTION
9 INSTRUCTIONAL ACTIVITIES
10 PILOT TEST
NEED REVISION?
YES
NO
11 LARGE-GROUP TRYOUT
VALID?
NO
YES
12 FIELD TEST
13 EVALUATE
14 DECISIONS REGARDING IMPLEMENTATION

CONSTRUCTING HIERARCHIES - Suggested Procedures

I. Introduction

- A. Provide class with copies of the topic description and objectives.
- B. Distribute several examples of hierarchies.
- C. Discuss the value and use of hierarchies (see topic description).

II. Instruction and Practice

- A. Discuss the techniques used to construct hierarchies.
- B. Have each member of the class do Activities 1-10.
- C. Check each completed activity and have participants make any necessary corrections before proceeding to the next activity.

III. Application

- A. Have each participant construct a hierarchy for his lesson segment.
- B. Have a technologist with a knowledge of the subject area or skill check the completed hierarchy and have participants make any necessary revisions.
- C. At this point, emphasize that the hierarchy is tentative and may be modified based on new knowledge or experience gained as the participants develop and evaluate the learning module.

IV. References

- A. Gagne, Robert M. The Conditions of Learning. New York: Holt, Rinehart and Winston, Inc., 1965, pp. 149-155.
- B. Walbesser, Henry H. Constructing Behavioral Objectives. College Park, Maryland: College of Education, University of Maryland, 1968, pp. 67-89.

FLOWCHARTING - Activity 11

Flowchart the survey test strategy described below.

> This is a series of four survey tests to determine whether the student has attained the terminal objective in each of the four arithmetic operations in whole numbers. Starting with addition, the student is presented five problems. If he does four of the five correctly, the student will go to the next survey test. He will continue until he has completed all four and then stop. In order to prevent the student from becoming frustrated by problems which may be too difficult, as soon as he does any two problems incorrectly, he is branched into a diagnostic test.

"FOR ME!"

Have your teachers learn to develop individualized learning modules.

Use the Project REFLECT publication,

Authoring Individualized Learning Modules:

A Teacher Training Manual

by Kenneth A. Walter

Now AVAILABLE AT COST from the Montgomery County Maryland Public Schools

(Details are on the other side.)

William M. Richardson, Director of

Project REFLECT

CAI Demonstration Project
(Title III, E.S.E.A. of 1965)

Montgomery County Public Schools
Rockville, Maryland
Homer O. Elseroad, Superintendent

proudly announces the November, 1970 publication of

Authoring Individualized Learning Modules: A Teacher Training Manual

This document by Kenneth A. Walter reflects the knowledge and experience gained through the development, operation and evaluation of orientation and training programs.

This instructor's manual outlines a learn-by-practice course for training experienced teachers to author individualized learning packages. Based on the sequential steps of producing learning materials, a variety of activities for diagnostic, instructional, and evaluative purposes are included. The manual is designed to allow the instructor to duplicate pages of appropriate materials or use them as a model for developing his own.

The manual is organized into four major parts: I. A Model for Individualizing Instruction, which presents a description of individualized instruction and an overview of instructional technology and the training course; II. Designing an Individualized Learning Module, which describes each successive step involved in planning and structuring the basic framework for a module and provides the learning activities necessary for the accomplishment of each step; III. Developing An Individualized Learning Module, which includes a description of the techniques required to write and revise a self-instructional package and provides learning activities for the acquisition of any necessary skills; and IV. Analysis and Assessment of Effectiveness, which provides a description of the procedures for insuring the module effectively teaches what it is designed to teach and for comparing the module with other instructional techniques and/or media.

Complete order form and shipping label. Please letter neatly.

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Please send me _____ copies of AUTHORING INDIVIDUALIZED LEARNING MODULES: A Teacher Training Manual @ $5.00 per copy. A check or money order for $________ is enclosed. (Make checks payable to Montgomery County Public Schools.)

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B. DISSEMINATION

Orientations, demonstrations, workshops, and seminars were held at the project during the summer of 1969 and the 1969-70 school year. In addition, project staff members spoke at various local, state, and national educational and technological conventions. Approximately 900 persons attended these functions.

In June, 1970, Dennis Cochran and Jeffrey Schultz, supporting teachers on the social studies design team, agreed to conduct orientations and workshop activities for the summer. From July 2 through July 30, a total of 390 persons participated in the project's activities, either as workshop visitors or members of college classes. A one-day seminar was held July 14 for 25 representatives from colleges of education in the surrounding area. Then on August 5, another one-day seminar was conducted for representatives from the Washington area public schools.

During the ensuing school year, the third year under Title III support, the dissemination activities of the project were substantially increased. Regular monthly visiting hours were scheduled. Records show that 1,945 individuals attended the project's demonstrations, either at the CAI facilities or at various conventions, from July, 1970, to July, 1971.

The Annual Report, June, 1968, to June, 1969, and *Authoring Individualized Learning Modules: A Teacher Training Manual* have been made available to persons and organizations interested in educational technology and computer-assisted instruction. Flyers describing the computer system, the steps in curriculum development, and each of the modular instructional packages (MIP's) have been printed and disseminated.

Many contacts acquired through the dissemination efforts have provided valuable insight, feedback, and knowledge into the area of computer-assisted instruction. Information relative to instructional and computer technology is vital to the decision-making tasks of instituting and implementing the use of computers in the public school system.

IV. OBSERVATIONS TO DATE AND PROJECTIONS

The use of the computer is slowly permeating the field of education. Its capacity for storage, assessment, branching, and retrieval has already made it a tremendous assist in the fields of commerce and industry. These business applications are now being utilized by many school administrations. Only in minor ways, however, is the computer being used in the instructional process. A limited number of school systems teach computer science and data processing to vocationally oriented students. Short-term experiences with time-sharing terminals are occurring in secondary school mathematics and science classes for the teaching of computer languages which, in turn, are used for problem solving. These efforts are fragmented, unstructured, and are often not evaluated and documented.

The Computer-Assisted Instruction Project has been concerned with an entirely different aspect of computer use. How and where can the computer's capabilities be used to facilitate the learning process? Psychologists state that learning occurs when (1) the learning is actively involved in the process; (2) the learner is reinforced in a positive manner; (3) the learner's chances of failure with resultant anxiety are reduced to a low level; and (4) the learner's characteristics, interests, and aptitudes are considered in providing the instructional environment.

When CAI and CMI programs are developed by teacher authors, using the systems approach to learning, and are then introduced into the curriculum by the classroom teacher for the purposes of individualization, each of the above learner needs is considered. The student interacts with the program, receives positive reinforcement, and proceeds step-by-step to a concept carefully monitored to drastically reduce his chances of failure. His entry level, his strengths and weaknesses, and his learning rate determine his instructional path.

Close coordination between project staff members and the faculties of the involved schools have minimized the problems of articulation. The use of the programs depends on the classroom teacher. He must observe that his students are receptive to and benefit from CAI and CMI use.

The three-year period (June, 1968, to July, 1971) designed to accomplish instituting and implementing this innovative program was inadequate. Validation studies conducted from 1969-1971 showed that CAI programs taught what they were designed to teach. Preliminary evaluations in algebra and arithmetic gave further evidence that students using CAI materials achieved significantly better in gain scores on standardized tests than students not using the materials. As more comparative evaluation was essential, the opportunity to extensively research the effectiveness and efficiency of the programs was actively sought.

Following a detailed evaluation of the project, the IBM Corporation announced in January, 1971, that the IBM 1500 Instructional System would be provided lease free to MCPS for the purpose of continuing the CAI effort during the fiscal years of 1972 and 1973. The 12.5 staff positions and other expenses of the CAI Project went under local MCPS support on July 1, 1971.

At least two institutions are concerned with the provision of large numbers of terminals to school systems, and, therefore, it is projected that the technological problem of providing numerous student stations will be overcome. Thus, it is extremely important that MCPS be involved in CAI research and development which may directly affect so many of its students in the future. Additional external funding will be actively sought to provide a pilot program to study the effects of a large terminal, comprehensive computer supported instructional program.